

# **ENERGY EFFICIENCY/RENEWABLE ENERGY IMPACT IN THE TEXAS EMISSIONS REDUCTION PLAN (TERP)**

## **VOLUME II—TECHNICAL REPORT**

**Annual Report to the  
Texas Commission on Environmental Quality  
January 2012-December 2012**



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**ENERGY SYSTEMS LABORATORY**  
TEXAS A&M ENGINEERING EXPERIMENT STATION



**TEXAS A&M ENGINEERING  
EXPERIMENT STATION**

**Energy Systems Laboratory**

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October 2, 2013

Chairman Bryan W. Shaw  
Texas Commission on Environmental Quality  
P. O. Box 13087  
Austin, TX 78711-3087

Dear Chairman Shaw:

The Energy Systems Laboratory (Laboratory) at the Texas Engineering Experiment Station of The Texas A&M University System is pleased to provide its ninth annual report, "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)," as required under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002 (Senate Bill 5, 77R as amended 78 R & 78S).

The Laboratory is required to annually report the energy savings from statewide adoption of the Texas Building Energy Performance Standards in Senate Bill 5 (SB 5), as amended, and the relative impact of proposed local energy code amendments in the Texas non-attainment and near-non-attainment counties as part of the Texas Emissions Reduction Plan (TERP).

Please contact me at (979) 845-1280 should you or any of the TCEQ staff have any questions concerning this report or any of the work presently being done to quantify emissions reduction from energy efficiency and renewable energy measures as a result of the TERP implementation.

Sincerely,

A handwritten signature in black ink that reads "David E. Claridge".

David E. Claridge, Ph.D., P.E.  
Director

Enclosure

cc: Commissioner Toby Baker  
Executive Director Zak Covar



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## VOLUME II – TECHNICAL REPORT

### Energy Efficiency/Renewable Energy Impact In The Texas Emissions Reduction Plan

#### Executive Summary

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of The Texas A&M University System, in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002, submits its ninth annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (TERP) to the Texas Commission on Environmental Quality.

The report is organized in three volumes.

Volume I – Summary Report – provides an executive summary and overview;

Volume II – Technical Report – provides a detailed report of activities, methodologies and findings;

Volume III – Technical Appendix – contains detailed data from simulations for each of the counties included in the analysis.

The ESL worked with the EPA and TCEQ regarding a new version of eGRID for all ERCOT counties in Texas. A new version of eGRID was developed and presented in this report, which is based on the ERCOT congestion management zones. As the TCEQ moved the base year to more recent years, this updated version of eGRID, representing the current Texas market, has been used to estimate the emissions reduction from wind power in the next year's report.

#### Accomplishments:

##### a. Energy Code Amendments

The Laboratory was requested by several Councils of Governments (COGs) and municipalities to analyze the stringency of several proposed residential and commercial energy code amendments, including: the 2003 and 2006 IECC and the ASHRAE Standards 90.1-2001 and 90.1-2004. Results of the analysis are included in this Volume II- Technical Report.

##### b. Technical Assistance

The Laboratory provided technical assistance to the TCEQ, PUCT, SECO, ERCOT, and several political subdivisions, as well as stakeholders participating in improving the compliance of the Texas Building Energy Performance Standards (TBEPS). The Laboratory also worked closely with the TCEQ to refine the integrated NO<sub>x</sub> emissions reduction calculation procedures that provide the TCEQ with a standardized, creditable NO<sub>x</sub> emissions reduction from energy efficiency and renewable energy (EE/RE) programs, which are acceptable to the US EPA. These activities have improved the accuracy of the creditable NO<sub>x</sub> emissions reduction from EE/RE initiatives contained in the TERP and have assisted the TCEQ, local governments, and the building industry with effective, standardized implementation and reporting.

##### c. NO<sub>x</sub> Emissions Reduction

Under the TERP legislation, the Laboratory must determine the energy savings from energy code adoption and, when applicable, from more stringent local codes or above-code performance ratings, and must report these reductions annually to the TCEQ.

Figure 1 shows the integrated NO<sub>x</sub> emissions reduction through 2020 for the electricity and natural gas savings from the various EE/RE programs.

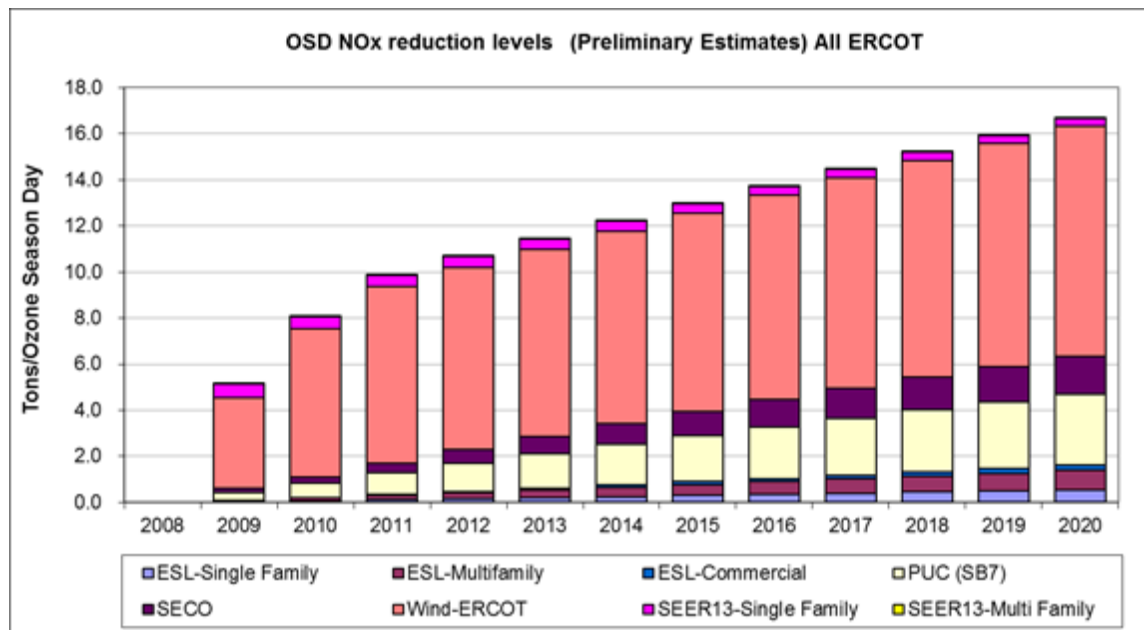


Figure 1: OSD NOx Emissions Reduction Projections through 2020 (Base Year 2008)

In 2012, (Table 1) the total integrated annual savings from all programs is 16,413,917 MWh/year. The integrated annual electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 498,883 MWh/year (3.0% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program is 1,831,318 MWh/year (11.2%),
- Savings from SECO's Senate Bill 5 program is 714,891 MWh/year (4.4%),
- Electricity savings from green power purchases (wind) is 13,049,580 MWh/year (79.5%), and
- Savings from residential air conditioner retrofits<sup>1</sup> is 319,244 MWh/year (1.9%).

By 2013, the total integrated annual savings from all programs will be 17,661,268 MWh/year. The integrated annual electricity savings from all the different programs will be:

- Savings from code-compliant residential and commercial construction will be 682,701 MWh/year (3.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 2,205,082 MWh/year (12.5%),
- Savings from SECO's Senate Bill 5 program will be 909,903 MWh/year (5.2%),
- Electricity savings from green power purchases (wind) will be 13,560,301 MWh/year (76.8%), and
- Savings from residential air conditioner retrofits will be 303,282 MWh/year (1.7%).

In 2012 (Table 2), the total integrated annual NOx emissions reduction from all programs is 4,609 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction is 126 tons-NOx/year (2.7% of the total NOx savings),
- NOx emissions reduction from the PUC's Senate Bill 7 programs is 522 tons-NOx/year (11.3%),
- NOx emissions reduction from SECO's Senate Bill 5 program is 221 tons-NOx/year (4.8%),
- NOx emissions reduction from green power purchases (wind) is 3,665 tons-NOx/year (79.5%), and
- NOx emissions reduction from residential air conditioner retrofits is 75 tons-NOx/year (1.6%).

<sup>1</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

By 2013, the total integrated annual NOx emissions reduction from all programs will be 4,959 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction will be 172 tons-NOx/year (3.5% of the total NOx savings),
- NOx emissions reduction from the PUC's Senate Bill 7 programs will be 629 tons-NOx/year (12.7%),
- NOx emissions reduction from SECO's Senate Bill 5 program will be 277 tons-NOx/year (5.6%),
- NOx emissions reduction from green power purchases (wind) will be 3,809 tons-NOx/year (76.8%), and
- NOx emissions reduction from residential air conditioner retrofits will be 71 tons-NOx/year (1.4%).

Table 1: Annual and OSD Electricity Savings for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	0	21,748	55,268	93,760	153,171	213,417	274,548	336,614	399,668	463,763	528,956	595,303	662,861
ESL-Multifamily (MWh)	0	50,218	94,867	167,566	262,939	357,885	452,435	546,620	640,469	734,013	827,282	920,305	1,013,111
ESL-Commercial (MWh)	0	0	25,750	54,550	82,773	111,399	140,452	169,957	199,937	230,420	261,430	292,996	325,145
PUC (SB7) (MWh)	0	538,841	976,984	1,437,883	1,831,318	2,205,082	2,560,158	2,897,479	3,217,935	3,522,368	3,811,579	4,086,330	4,347,343
SECO (MWh)	0	235,216	293,537	509,616	714,891	909,903	1,095,163	1,271,161	1,438,359	1,597,197	1,748,093	1,891,444	2,027,628
Wind-ERCOT (MWh)	0	3,273,150	8,135,429	10,995,427	13,049,580	13,560,301	14,091,009	14,642,488	15,215,550	15,811,039	16,429,835	17,072,848	17,741,026
SEER13-Single Family (MWh)	0	343,330	326,163	309,855	294,362	279,644	265,662	252,379	239,760	227,772	216,383	205,564	195,286
SEER13-Multifamily (MWh)	0	29,021	27,569	26,191	24,881	23,637	22,456	21,333	20,266	19,253	18,290	17,376	16,507
<b>Total Annual (MWh)</b>	0	4,491,524	9,935,568	13,594,848	16,413,917	17,661,268	18,901,882	20,138,030	21,371,943	22,605,825	23,841,849	25,082,165	26,328,906

PROGRAM	OZONE SEASON DAY - OSD												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	0	124	283	468	626	787	951	1,117	1,286	1,457	1,632	1,810	1,992
ESL-Multifamily (MWh)	0	233	460	744	999	1,254	1,508	1,760	2,012	2,263	2,514	2,764	3,013
ESL-Commercial (MWh)	0	0	71	149	227	305	385	466	548	631	716	803	891
PUC (SB7) (MWh)	0	1,476	2,677	3,939	5,017	6,041	7,014	7,938	8,816	9,650	10,443	11,195	11,911
SECO (MWh)	0	644	804	1,396	1,959	2,493	3,000	3,483	3,941	4,376	4,789	5,182	5,555
Wind-ERCOT (MWh)	0	14,246	23,054	27,654	33,273	34,575	35,929	37,335	38,796	40,314	41,892	43,532	45,235
SEER13-Single Family (MWh)	0	2,445	2,323	2,207	2,097	1,992	1,892	1,798	1,708	1,622	1,541	1,464	1,391
SEER13-Multifamily (MWh)	0	195	186	176	167	159	151	144	136	130	123	117	111
<b>Total OSD (MWh)</b>	0	19,365	29,857	36,734	44,366	47,607	50,830	54,039	57,242	60,444	63,651	66,867	70,099

Table 2: Annual and OSD NOx Emissions Reduction Values for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL (in tons NOx)													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
ESL-Single Family	0	5	14	23	38	53	68	83	99	115	131	147	164	
ESL-Multi family	0	13	24	43	67	92	117	141	166	190	214	239	263	
ESL-Commercial	0	0	6	14	21	28	35	42	50	57	65	73	81	
PUC (SB7)	0	151	274	409	522	629	731	828	921	1,008	1,091	1,170	1,245	
SECO	0	67	99	162	221	277	330	381	429	475	518	559	599	
Wind-ERCOT	0	893	2,268	3,062	3,665	3,809	3,958	4,113	4,274	4,441	4,615	4,796	4,983	
SEER13-Single Family	0	81	77	73	69	66	62	59	56	53	51	48	46	
SEER13-Multifamily	0	7	6	6	6	6	5	5	5	5	4	4	4	
Total Annual (Tons NOx)	0	1,217	2,769	3,790	4,609	4,959	5,307	5,653	5,999	6,344	6,690	7,036	7,384	

PROGRAM	OZONE SEASON DAY - OSD (in tons NOx/day)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	0.00	0.03	0.07	0.11	0.15	0.19	0.23	0.28	0.32	0.36	0.40	0.45	0.49
ESL-Multifamily	0.00	0.06	0.12	0.19	0.26	0.32	0.39	0.45	0.52	0.58	0.65	0.72	0.78
ESL-Commercial	0.00	0.00	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.22
PUC (SB7)	0.00	0.41	0.75	1.12	1.43	1.72	2.00	2.27	2.52	2.76	2.99	3.21	3.41
SECO	0.00	0.18	0.27	0.44	0.60	0.76	0.90	1.04	1.18	1.30	1.42	1.53	1.64
Wind-ERCOT	0.00	3.94	6.42	7.63	9.32	9.69	10.06	10.46	10.87	11.29	11.74	12.19	12.67
SEER13-Single Family	0.00	0.57	0.54	0.51	0.49	0.46	0.44	0.42	0.40	0.38	0.36	0.34	0.32
SEER13-Multifamily	0.00	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
<b>Total OSD (Tons NOx)</b>	<b>0.00</b>	<b>5.24</b>	<b>8.23</b>	<b>10.09</b>	<b>12.35</b>	<b>13.26</b>	<b>14.16</b>	<b>15.07</b>	<b>15.97</b>	<b>16.86</b>	<b>17.76</b>	<b>18.66</b>	<b>19.57</b>

#### 4. Technology Transfer

The Laboratory, along with the TCEQ, hosts the annual Clean Air Through Energy Efficiency (CATEE) conference, which is attended by top experts and policy makers in Texas and from around the country. At the conference, the latest educational programs and technology is presented and discussed, including efforts by the Laboratory, and others, to reduce air pollution in Texas through energy efficiency and renewable energy. These efforts have produced significant success in bringing EE/RE closer to US EPA acceptance in the Texas SIP. The Laboratory will continue to provide superior technology to the State of Texas through such efforts with the TCEQ and the US EPA.

To accelerate the transfer of technology developed as part of the TERP, the Laboratory has also made presentations at national, state and local meetings and conferences, which includes the publication of peer-reviewed papers. The Laboratory will continue to provide technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans.

These efforts have been recognized nationally by the US EPA. In 2007, the Laboratory was awarded a National Center of Excellence on Displaced Emissions Reduction (CEDER) by the US EPA so that these accomplishments could be rapidly disseminated to other states for their use. The benefits of CEDER include:

- Reducing the financial, technical, and administrative costs of determining the emissions reduction from EE/RE measures;
- Continuing to accelerate implementation of EE/RE strategies as a viable clean air effort in Texas and other states;
- Helping other states better identify and prioritize cost-effective clean air strategies from EE/RE; and
- Communicating the results of quantification efforts through case-studies and a clearinghouse of information.

The Energy Systems Laboratory provides the annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (TERP), to the Texas Commission on Environmental Quality (TCEQ) in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002. If any questions arise, please contact us by phone at 979-862-2804, or by email at [terpinfo@tees.tamus.edu](mailto:terpinfo@tees.tamus.edu).

### Acknowledgements

This work has been completed as a fulfillment of the requirements in Texas Health Code, Senate Bill 5, Section 388.003, and through Senate Bill 20, House Bill 2481 and House Bill 2129, which requires the Laboratory to assist TCEQ in quantifying emissions reductions credits from energy efficiency and renewable energy programs, through a contract with the Texas Environmental Research Consortium (TERC). Similarly, selected Code training workshops were funded by the US DOE through the Texas State Energy Conservation Office (SECO). Partial funding on the Texas Climate Vision project, a joint project with the City of Austin was also provided by the US DOE through SECO.

The authors are also grateful for the timely input provided by the following individuals, and agencies: Mr. Art Diem, US EPA, for providing the eGRID database and Vincent Meiller and Robert Gifford, TCEQ.

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## 1. Overview

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of the Texas A&M University System, is pleased to provide our ninth annual report, Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP), to the Texas Commission on Environmental Quality (TCEQ) in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002. This annual report:

- Provides an estimate of the energy savings and NOx reductions from energy code compliance in new residential construction in all ERCOT counties;
- Provides an estimate of the standardized, cumulative, integrated energy savings and NOx reductions from the TERP programs implemented by the Laboratory, SECO, the PUC and ERCOT in all ERCOT Texas;
- Describes the technology developed to enable the TCEQ to substantiate energy and emissions reduction credits from energy efficiency and renewable energy initiatives (EE/RE) to the U.S. Environmental Protection Agency (US EPA), including the development of a web-based emissions reduction calculator; and
- Outlines progress in advancing EE/RE strategies for credit in the Texas State Implementation Plan (SIP).

The report is organized in three volumes.

Volume I – Summary Report – provides an executive summary and overview;

Volume II – Technical Report – provides a detailed report of activities, methodologies and findings; and

Volume III – Technical Appendix – contains detailed data from code-compliant energy simulations for all ERCOT counties in Texas included in the analysis.

### 1.1 Legislative Background

The TERP was established in 2001 by the 77<sup>th</sup> Legislature through the enactment of Senate Bill 5 to:

- Ensure that Texas air meets the Federal Clean Air Act requirements (Section 707, Title 42, United States Code); and
- Reduce NOx emissions in non-attainment and near-non-attainment counties through mandatory and voluntary programs, including the implementation of energy efficiency and renewable energy programs (EE/RE).

To achieve the clean air and emissions reduction goals of the TERP, Senate Bill 5 created a number of EE/RE programs for credit in the SIP:

- The Texas Building Energy Performance Standards (TBEPS) as the building energy code for all new residential and commercial buildings;
- A municipality or county may request the Laboratory to determine the energy impact of proposed energy code changes;
- An annual evaluation by the Public Utility Commission of Texas (PUCT), in cooperation with the Laboratory, of the emissions reduction of energy demand, peak electric loads and the associated air contaminant reductions from utility-sponsored programs established under Senate Bill 5, and utility-sponsored programs established under the electric utility restructuring act (Section 39.905 Utilities Code);
- A 5% electricity reduction goal each year for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2009; and
- Annual report to TCEQ to be provided by the Laboratory on the energy savings and resultant emissions reduction from implementation of building energy codes and which identifies the municipalities and counties whose codes are more or less stringent than the un-amended code.

Passed during the 78<sup>th</sup> Legislature (2003), HB 1365 and HB 3235 amended TERP to enhance its effectiveness with these additional energy efficiency initiatives:

- TCEQ is required to conduct outreach to non-attainment and near-non-attainment counties on the benefits of implementing energy efficiency measures as a way to meet the air quality goals under the federal Clean Air Act;
- TCEQ is required develop a methodology for computing emissions reduction from energy efficiency initiatives;
- A voluntary Energy-Efficient Building Program at the General Land Office (GLO), in consultation with the Laboratory, for the accreditation of buildings that exceed the state energy code requirements by 15% or more;

- Municipalities are allowed to adopt an optional, alternate energy code compliance mechanism through the use of accredited energy efficiency programs determined to be code-compliant by the Laboratory, as well as the US EPA's Energy Star New Homes program; and
- The Laboratory is required to develop and administer a statewide training program for municipal building inspectors seeking to become code-certified inspectors for enforcement of energy codes.

Senate Bill 5 was again amended during the 79<sup>th</sup> Legislature (2005) through SB 20, HB 2481 and HB 2129. These enhanced the effectiveness of Senate Bill 5 by adding the following energy efficiency initiatives:

- 5,880 MW of generating capacity is required from renewable energy technologies by 2015;
- 500 MW from non-wind renewables;
- The PUCT is required to establish a target of 10,000 megawatts of installed renewable capacity by 2025;
- The TCEQ is required to develop methodology for computing emissions reduction from renewable energy initiatives and the associated credits;
- The Laboratory is required to assist the TCEQ in quantifying emissions reduction credits from energy efficiency and renewable energy programs;
- The Texas Environmental Research Consortium (TERC) is required to contract with the Laboratory to develop and annually calculate creditable emissions reduction from wind and other renewable energy resources for the state's SIP; and
- The Laboratory is required to develop at least three alternative methods for achieving a 15 % greater potential energy savings in residential, commercial and industrial construction.

The 80<sup>th</sup> Legislature (2007), through SB 12, and HB 3693 further amended Senate Bill 5 to enhance its effectiveness by adding the following energy efficiency initiatives:

- The Laboratory is required to provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC) or the International Energy Conservation Code (IECC) are equivalent to or better than the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC. The Laboratory shall make its recommendations no later than six months after publication of new editions at the end of each three-year code development cycle of the International Residential Code and the International Energy Conservation Code.
- The Laboratory is required to consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- The Laboratory is required to develop a standardized report format to be used by providers of home energy ratings, including different report formats for rating newly constructed residences from those for existing residences. The form must be designed to give potential buyers information on a structure's energy performance, including: insulation; types of windows; heating and cooling equipment; water heating equipment; additional energy conserving features, if any; results of performance measurements of building tightness and forced air distribution; and an overall rating of probable energy efficiency relative to the minimum requirements of the International Energy Conservation Code or the energy efficiency chapter of the International Residential Code, as appropriate.
- The Laboratory is encouraged to cooperate with an industry organization or trade association to: develop guidelines for home energy ratings; provide training for individuals performing home energy ratings and providers of home energy ratings; and provide a registry of completed ratings for newly constructed residences and residential improvement projects for the purpose of computing the energy savings and emissions reduction benefits of the home energy ratings program.
- The Laboratory is required to include information on the benefits attained from this program in an annual report to the commission.

The 81<sup>st</sup> Legislature (2009) extended the date of the TERP to 2019 and required the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

The 82<sup>nd</sup> Legislature (2011) cut 50% of the Laboratory's funding under TERP (to take into effect in FY 2012), while the Laboratory's responsibilities under TERP increased, as new legislatively allocated energy efficiency initiatives were introduced:

- Each political subdivision, institution of higher education or state agency shall establish a goal to reduce the electric consumption by the entity by at least 5% each fiscal year for 10 years, beginning September 1, 2011. Each entity annually shall report to SECO, on forms provided by SECO, regarding the entity's goal, the entity's efforts to meet the goal, and progress the entity has made. The Laboratory is required to calculate energy savings and emissions reduction for each political subdivision, institution of higher education or state agency, based on the information collected by SECO.
- Beginning April 1, 2012, all electric cooperatives that had retail sales of more than 500,000 MWh in 2005 and all municipally owned utilities must report each year to SECO, on a standardized form developed by SECO, information regarding the combined effects of the energy efficiency activities of the electric cooperative/utility from the previous calendar year, including the annual goals, programs enacted to achieve those goals, and any achieved energy demand or savings goals. The Laboratory is required to calculate energy savings and emissions reduction for municipally owned utilities and for electric cooperatives, based on the information collected by SECO.
- SECO is required to appoint a new advisory committee for selecting high-performance building design evaluation systems. The Laboratory will send a representative to participate at the new advisory committee.
- The Laboratory may conduct outreach to the real estate industry on the value of energy code compliance and above code construction.

The 83<sup>rd</sup> Legislature (2013) kept the Laboratory's funding under TERP at 50% of the legislatively allocated level, while the Laboratory's responsibilities under TERP were not similarly reduced.

## 1.2 Laboratory Funding for the TERP

The Laboratory expended \$181,855 in FY 2002; \$372,226 in FY 2003; \$635,683.84 in FY 2004; \$1,107,366.13 in FY 2005; \$952,012.70 in FY 2006; \$947,114.62 in FY 2007; \$908,512.65 in FY 2008; \$949,927.94 in FY 2009; \$902,843.35 in FY 2010; \$853,421.69 in FY 2011; and \$434,481.91 in FY 2012 (with the 50% Legislature cut in ESL funding). In FY 2013 the Laboratory expended \$447,221.42. The Laboratory has also supplemented these funds with competitively awarded Federal and State grants to provide the needed statewide training for the new mandatory energy codes and to provide technical assistance to cities and counties in helping them implement adoption of the legislated energy efficiency codes. In addition, the ESL received an award from the US EPA in the spring of 2007 to establish a Center of Excellence for the Determination of Emissions Reduction (CEDER) which has helped to enhance the EE/RE emissions calculations

## 1.3 Accomplishments since January 2012

Since January 2012, the Laboratory has accomplished the following:

- Calculated energy and resultant NO<sub>x</sub> reductions from implementation of the Texas Building Energy Performance Standards (IECC/IRC codes) to new residential and commercial construction for all non-attainment and near-non-attainment counties;
- Enhanced the Laboratory's IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;

- Enhanced the IC3 calculator, which is energy code compliance software based on the Texas Building Energy Performance Standards by resolving minor defects found in the model, introducing new capability to add slab and floor insulation to IC3 interface, and updating manual and illustrations;
  - Continued development and testing of key procedures for validating simulations of building energy performance;
  - Provided energy code training workshops, including: residential, commercial IECC/IRC energy code training sessions, ASHRAE 90.1-2010 (funded by SECO), and other educational workshops on strategies to advance high performance homes and buildings [funded by SECO and provided in collaboration with the South-central Partnership for Energy Efficiency as a Resource (SPEER)] throughout the State of Texas;
  - Maintained and updated the Laboratory's Texas Emissions Reduction Plan (TERP) website;
  - Maintained a builder's residential energy code Self-Certification Form (Ver.1.3) for use by builders outside municipalities;
  - Analyzed the stringency of Chapter 11, 2012 International Residential Code (IRC) and the 2012 International Energy Conservation Code (IECC) versus the current Texas Building Energy Performance Standards (TBEPS), based on Chapter 11 of the 2009 IRC and the 2009 IECC. The Laboratory also reviewed and considered the 1,526 public comments collected by SECO. The Laboratory presented to SECO its final recommendation on the adoption of the 2012 code.
  - Reviewed several local code proposed amendments and analyzed their stringency. For: the City of Houston and the North Central Texas Council of Governments (NCTCOG).
  - Hosted the Clean Air Through Energy Efficiency (CATEE) Conference in October 2012, in Galveston, Texas. Conference sessions included key talks by the TCEQ, PUCT, ERCOT, EPA, DOE the 1st Armored Division and Fort Bliss, Texas House of representatives Oncor, several ISDs and cities, NASA, SECO and the Laboratory about quantifying emissions reduction from EE/RE opportunities and guidance on key energy efficiency and renewable energy topics;
  - Provided technical assistance to the TCEQ regarding specific issues, including:
    - Enhancement of the standardized, integrated NOx emissions reduction reporting procedures to the TCEQ for EE/RE projects;
    - Enhancement of the procedures for weather normalizing NOx emissions reduction from renewable projects;
  - Enhanced the web-based emissions reduction calculator, including:
    - Depreciated the 2000/2001 and 2006 IECC codes (as of 1/1/2012)
    - Added the 2009 IECC version
    - Added a version of the energy report with a signature line, as requested by some municipalities,
    - Improved the algorithm behind IC3 to make it more accurate
    - Altered the help text and images to make it clearer
    - Added optional inputs for water heaters to make the calculation more accurate.
  - Participated as exhibitors at several conferences, including at the Clean Air Through Energy Efficiency Conference in Galveston, Texas, the Texas Green Home Summit in Plano, Texas, and TCEQ Environmental Trade Fair and Conference, Austin, Texas.
  - Completed the study for the City of Arlington on the economic and environmental impacts of potential energy code enhancements for the city. The project identified up to 16 Energy Efficiency Measures (EEMs) for various building energy components (e.g., windows, doors, insulation; lighting; HVAC; and domestic water heating). Combinations of EEMs were used to deliver 15% above the energy code stringency. The study and recommendations included both residential and commercial new development and existing building inventory (as an option).
  - Assisted SECO in the development of a form for political subdivisions, institutions of higher education and state agency to report annually on energy efficiency activities and results towards achieving the goal of at least 5% annual reduction in electric consumption.
  - Assisted SECO in the development of a form for electric cooperatives that had retail sales of more than 500,000 MWh in 2005 and all municipally owned utilities, to report annually on energy efficiency activities and energy saving/demand reduction.
  - Continued the development of verification procedures, including:
- Worked toward the code compliance tools for commercial buildings, retail and school buildings



#### 1.4 Technology Transfer

To accelerate the transfer of technology developed as part of the TERP program, the Laboratory:

- Delivered “Statewide Air Emissions Calculations from Wind and Other Renewables,” to the Texas Commission on Environmental Quality in December 2012.
- Updated previously developed degradation analysis to determine if degradation could be observed in the measured power from Texas wind farms.
- Updated previously developed database of other renewable projects in Texas, including: solar photovoltaic, geothermal, hydroelectric, and Landfill Gas-fired Power Plants.
- Applied previously developed estimation techniques for hourly solar radiation from limited data sets.
- Along with the TCEQ and the US EPA, is host to the annual Clean Air Through Energy Efficiency (CATEE) Conference attended by top Texas experts and policy makers and national experts.
- Continued the National Center of Excellence on Displaced Emissions Reduction (CEDER) by the US EPA. The benefits of CEDER include:
  - Reducing the financial, technical, and administrative costs of determining the emissions reduction from EE/RE measures;
  - Continuing to accelerate implementation of EE/RE strategies as a viable clean air effort in Texas and other states;
  - Helping other states identify and prioritize cost-effective clean air strategies from EE/RE, and;
  - Communicating the results of quantification efforts through case-studies and a clearinghouse of information.

In addition to the tasks listed above, the Laboratory delivered presentations regarding the TERP related work, including:

- Presentation to the City of Arlington, February 2012
- Presentations to the Building Professional Institute, February & May 2012
- Presentations to the City of Corpus Christi, March 2012
- Presentation to the Sierra Club, June 2012
- Presentations at Stakeholder’s meeting, July 2012 and August 2012
- Presentation to the International Building Performance Simulation Association (IBPSA), Madison, WS, August 2012
- Webinar to the Environmental Protection Agency (EPA), August 2012
- Presentations to the City of El Paso, September 2012
- Presentations to SPEER, September, October and December 2012
- Presentation to the International Conference for Enhanced Building Operations, Manchester, United Kingdom, October 2012
- Presentations to the Clean Air Through Energy Efficiency Conference, Galveston, TX, October 2012
- Presentations to The South-central Partnership for Energy Efficiency as a Resource (SPEER), September 2012, October 2012 and December 2012

Four presentations to the City of Arlington

- Mukhopadhyay, J.; Kim, H.; Do, S.L.; Kim, K.H.; Baltazar, J-C; Haberl, J.; Lewis, C. 2011 “Cost-Effective Energy Efficiency Measures for Above Code (ASHRAE 90.1-2001 and 2007) Restaurant Buildings in the City of Arlington,” City of Arlington and Stakeholders, February 2012
- Kim, H.; Do, S.L.; Baltazar, J-C; Haberl, J.; Lewis, C. 2011 “Cost-Effective Energy Efficiency Measures for Above Code (2003 and 2009 IECC) Residential Buildings in the City of Arlington,” City of Arlington and Stakeholders, February 2012

- Kim, H.; Do, S.L.; Kim, K.H.; Baltazar, J.-C.; Haberl, J.; Lewis, C. 2011 “Cost-Effective Energy Efficiency Measures for Above Code (ASHRAE 90.1-2001 and 2007) Small Retail Buildings in the City of Arlington,” City of Arlington and Stakeholders, February 2012
- Kim, H.; Do, S.L.; Kim, K.H.; Baltazar, J.-C.; Haberl, J.; Lewis, C. 2011 “Cost-Effective Energy Efficiency Measures for Above Code (ASHRAE 90.1-2001 and 2007) Small Office Buildings in the City of Arlington,” City of Arlington and Stakeholders, February 2012

Presentation of one paper at the 12<sup>th</sup> International Conference for Enhanced Building Operations, held in Manchester, UK, October 2012

- Yazdani, B.; Haberl, J.; Kim, H.; Baltazar, J.C.; Zilbershtein, G. 2012 “Statewide Emissions Reduction, Electricity and Demand Savings from the Implementation of Building-Energy-Codes in Texas,” *Proceedings of the 12<sup>th</sup> International Conference for Enhanced Building Operations*, Manchester, United Kingdom

Three presentations to the Clean Air Through Energy Efficiency Conference held in Galveston, Texas, October 2012.

- Kim, H.; Haberl, J.; Mukhopadhyay, J.; Baltazar, J.C.; Do, S.; Kim, K.; Yazdani, B.; Yarborough, J., 2012 “Energy Efficiency / Renewable Energy (EE/RE) Projects in Texas Public Schools: Top Four Measures,” *Clean Air Through Energy Efficiency Conference*, Galveston, Texas, October 2012
- Haberl, J.; Yazdani, B.; Culp, 2012 “Emissions Reduction Impact of Renewables,” *Clean Air Through Energy Efficiency Conference*, Galveston, Texas, October 2012
- Haberl, J.; Yazdani, B.; Culp, 2012 “Texas Emissions Reductions Program (TERP) Energy Efficiency/Renewable Energy (EE/RE) Update,” *Clean Air Through Energy Efficiency Conference*, Galveston, Texas, October 2012

The Laboratory has and will continue to provide leading-edge technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP. These activities were designed to more accurately calculate the creditable NO<sub>x</sub> emissions reduction from EE/RE initiatives contained in the TERP and to assist the TCEQ, local governments, and the building industry with standardized, effective implementation and reporting.

### 1.5 Energy and NO<sub>x</sub> Reductions from New Residential and Commercial Construction, Including Residential Air Conditioner Retrofits

State adoption of the energy efficiency provisions of the International Residential Code (IRC) and International Energy Conservation Code (IECC) became effective September 1, 2001. The Laboratory has developed and delivered training to assist municipal inspectors to become certified energy inspectors. The Laboratory also supported code officials with guidance on interpretations as needed. This effort, based on a requirement of HB 3235, 78<sup>th</sup> Texas Legislature, supports a more uniform interpretation and application of energy codes throughout the state. In general, the State is experiencing a true market transformation from low energy efficiency products to high

energy efficiency products. These include: low solar heat gain windows, higher efficiency appliances, high efficiency air conditioners and heat pumps, increased insulation, lower thermal loss ducts and in-builder participation in “above-code” code programs such as Energy Star New Homes, which previously had no state baseline and almost no participation.

In 2012, the following savings were calculated:

- In 2012, the annual electricity savings from code-compliant residential and commercial construction is calculated to be 498,883 MWh/year (3.0% of the total electricity savings),
- Savings from residential air conditioner retrofits<sup>2</sup> is 319,244 MWh/year (1.9%).
- In 2012, the OSD electricity savings from code-compliant residential and commercial construction is calculated to be 1,852 MWh/day (4.2%),
- Savings from residential air conditioner retrofits are 2,264 MWh/day (5.1%).
- By 2013, the annual electricity savings from code-compliant residential and commercial construction is calculated to be 682,701 MWh/year (3.9% of the total electricity savings),
- Savings from residential air conditioner retrofits will be 303,282 MWh/year (1.7%).
- By 2013, the OSD electricity savings from code-compliant residential and commercial construction is calculated to be 2,346 MWh/day (4.9%),
- Savings from residential air conditioner retrofits will be 2,151 MWh/day (4.5%).
- In 2012, the annual NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 126 tons-NOx/year (2.7% of the total NOx savings),
- Savings from residential air conditioner retrofits is 75 tons-NOx/year (1.6%).
- In 2012, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 0.47 tons-NOx/day (3.8%),
- Savings from residential air conditioner retrofits are 0.53 tons-NOx/day (4.3%).
- By 2013, the NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 172 tons-NOx/year (3.5% of the total NOx savings),
- Savings from residential air conditioner retrofits will be 71 tons-NOx/year (1.4%).
- By 2013, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 0.59 tons-NOx/day (4.5%),
- Savings from residential air conditioner retrofits will be 0.50 tons-NOx/day (3.8%).

### *1.6 Integrated NOx Emissions Reductions Reporting Across State Agencies*

In 2005, the Laboratory began to work with the TCEQ to develop a standardized, integrated NOx emissions reduction across state agencies implementing EE/RE programs so that the results can be evaluated consistently. As required by the legislation, the TCEQ receives the following reports:

- From the Laboratory – savings from code compliance and renewables;
- From the Laboratory, in cooperation with the Electric Reliability Council of Texas (ERCOT), the savings from electricity generated from wind power;
- From the Public Utilities Commission of Texas (PUCT) on the impacts of the utility-administered programs designed to meet the mandated energy efficiency goals of SB7 and SB5; and

<sup>2</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- From the State Energy Conservation Office (SECO) on the impacts of energy conservation in state agencies and political subdivisions.

The total integrated annual and OSD electricity savings for all the different programs in the integrated format was calculated using the adjustment factors shown in Table 3 for 2009 through 2020 as shown in Table 1. Annual and OSD NOx emissions reduction from the electricity savings (presented in Table 1) for all the programs in the integrated format is shown in Table 2.

In 2012, the total integrated annual savings from all programs is 16,413,917 MWh/year. The integrated annual electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 498,883 MWh/year (3.0% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program is 1,831,318 MWh/year (11.2%),
- Savings from SECO's Senate Bill 5 program is 714,891 MWh/year (4.4%),
- Electricity savings from green power purchases (wind) is 13,049,580 MWh/year (79.5%), and
- Savings from residential air conditioner retrofits<sup>3</sup> is 319,244 MWh/year (1.9%).

In 2012, the total integrated OSD savings from all programs is 44,366 MWh/day, which would be a 1,849 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 1,852 MWh/day (4.2%),
- Savings from the PUC's Senate Bill 7 programs is 5,017 MWh/day (11.3%),
- Savings from SECO's Senate Bill 5 program is 1,959 MWh/day (4.4%),
- Electricity savings from green power purchases (wind) are 33,273 MWh/day (75.0%), and
- Savings from residential air conditioner retrofits are 2,264 MWh/day (5.1%).

By 2013, the total integrated annual savings from all programs is 17,661,268 MWh/year. The integrated annual electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 682,701 MWh/year (3.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program is 2,205,082 MWh/year (12.5%),
- Savings from SECO's Senate Bill 5 program is 909,903 MWh/year (5.2%),
- Electricity savings from green power purchases (wind) is 13,560,301 MWh/year (76.8%), and
- Savings from residential air conditioner retrofits is 303,282 MWh/year (1.7%).

By 2013, the total integrated OSD savings from all programs is 47,607 MWh/day, which would be a 1,984 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 2,346 MWh/day (4.9%),
- Savings from the PUC's Senate Bill 7 programs is 6,041 MWh/day (12.7%),
- Savings from SECO's Senate Bill 5 program is 2,493 MWh/day (5.2%),
- Electricity savings from green power purchases (wind) are 34,575 MWh/day (72.6%), and
- Savings from residential air conditioner retrofits are 2,151 MWh/day (4.5%).

In 2012, the total integrated annual NOx emissions reduction from all programs is 4,609 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction is 126 tons-NOx/year (2.7% of the total NOx savings),
- NOx emissions reduction from the PUC's Senate Bill 7 programs is 522 tons-NOx/year (11.3%),
- NOx emissions reduction from SECO's Senate Bill 5 program is 221 tons-NOx/year (4.8%),

<sup>3</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- NOx emissions reduction from green power purchases (wind) is 3,665 tons-NOx/year (79.5%), and
- NOx emissions reduction from residential air conditioner retrofits is 75 tons-NOx/year (1.6%).

In 2012, the total integrated OSD NOx emissions reduction from all programs is 12.35 tons-NOx/day. The integrated OSD NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction is 0.47 tons-NOx/day (3.8%),
- NOx emissions reduction from the PUC's Senate Bill 7 programs is 1.43 tons-NOx/day (11.6%),
- NOx emissions reduction from SECO's Senate Bill 5 program is 0.60 tons-NOx/day (4.9%),
- NOx emissions reduction from green power purchases (wind) are 9.32 tons-NOx/day (75.5%), and
- NOx emissions reduction from residential air conditioner retrofits are 0.53 tons-NOx/day (4.3%).

By 2013, the total integrated annual NOx emissions reduction from all programs will be 4,959 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction will be 172 tons-NOx/year (3.5% of the total NOx savings),
- NOx emissions reduction from the PUC's Senate Bill 7 programs will be 629 tons-NOx/year (12.7%),
- NOx emissions reduction from SECO's Senate Bill 5 program will be 277 tons-NOx/year (5.6%),
- NOx emissions reduction from green power purchases (wind) will be 3,809 tons-NOx/year (76.8%), and
- NOx emissions reduction from residential air conditioner retrofits will be 71 tons-NOx/year (1.4%).

By 2013, the total integrated OSD NOx emissions reduction from all programs is 13.26 tons-NOx/day. The integrated OSD NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction will be 0.59 tons-NOx/day (4.5%),
- NOx emissions reduction from the PUC's Senate Bill 7 programs will be 1.72 tons-NOx/day (13.0%),
- NOx emissions reduction from SECO's Senate Bill 5 program will be 0.76 tons-NOx/day (5.7%),
- NOx emissions reduction from green power purchases (wind) will be 9.69 tons-NOx/day (73.1%), and
- NOx emissions reduction from residential air conditioner retrofits will be 0.50 tons-NOx/day (3.8%).

Table 3: Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs

	ESL- Single Family	ESL- Multi Family	ESL- Commercial	PUC (SB7)	SECO	Wind-ERCOT	SEER13 Single Family	SEER13 Multi Family
Annual Degradation Factor	2.00%	2.00%	2.00%	5.00%	5.00%	0.00%	5.00%	5.00%
T&D Loss	7.00%	7.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%
Initial Discount Factor	20.00%	20.00%	20.00%	25.00%	60.00%	10.00%	20.00%	20.00%
Growth Factor	3.25%	1.54%	3.25%	0.00%	0.00%	Actual Rates	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	See note 7	Yes	Yes

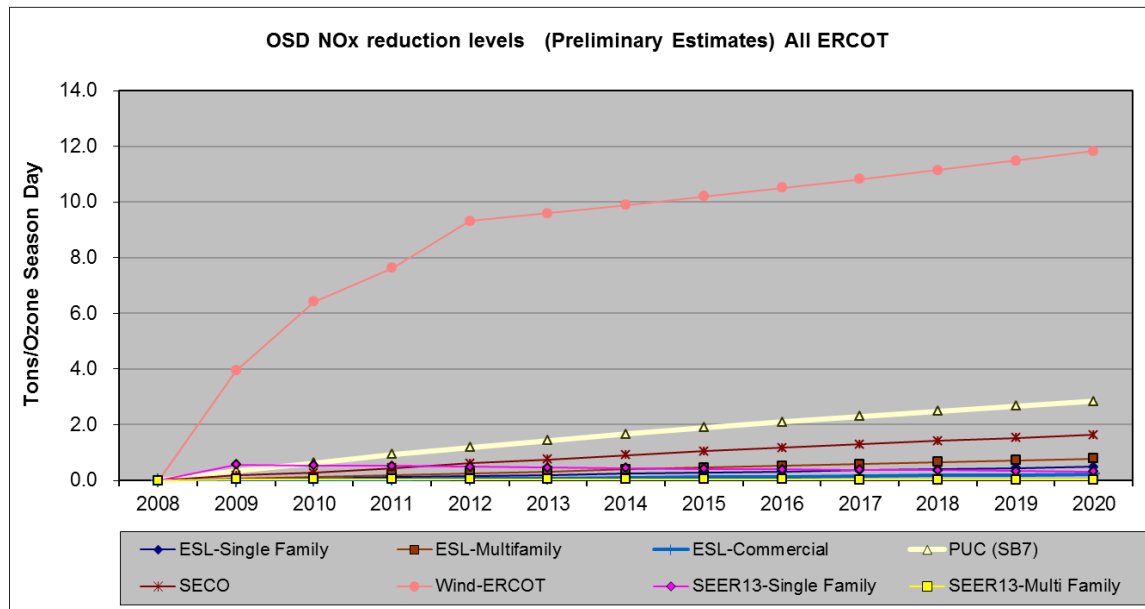


Figure 2: Integrated OSD NOx Emissions Reduction Projections through 2020 (Base Year 2008)

### 1.7 Technology for Calculating and Verifying Emissions Reduction from Energy Used in Buildings

In 2004 and 2005, the Laboratory developed a web-based Emissions Reduction Calculator, known as “*eCalc*,” which contains the underlying technology for determining NOx emissions reduction from power plants that generate the electricity for the user<sup>4</sup>. The emissions reduction calculator is being used to calculate emissions reduction for consideration for SIP credits from energy efficiency and renewable energy programs in the TERP.

In 2007, the Laboratory enhanced the calculator to provide additional functions and usability, including:

- Renaming the product IC3 v2.0
- Enhanced the Laboratory’s IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;
- Enhanced web-based emissions calculator, including:
  - Use of the calculator to determine 15% above code residential and commercial options.
  - Gathered, cleaned and posted weather data archive for 17 NOAA stations;
  - Performed comparative testing of the calculator vs. other, non-web-based simulation programs;
  - Developed and tested radiant barrier simulation;
  - Using the web-based emissions calculator, started development of the derivative version Texas Climate Vision calculator for the City of Austin;
- Continued the development of verification procedures, including:
  - Completed the calibrated simulation of a high-efficiency office building in Austin, Texas;
  - Continued work to develop a calibrated simulation of an office building in College Station; and
  - Continued work to develop a calibrated simulation of a K-12 school in College Station;

In 2008, work on both web based calculators continued;

- Deployed IC3 v3.2 to handle a wider selection of single family building configurations (<http://ic3.tamu.edu>);
- Delivered TCV v1.0 to the City of Austin for their testing;
- Continued to operate the original eCalc;
- Supported modeling efforts by building enhanced tools for batch simulation;
- Provided training on both IC3 and TCV.

<sup>4</sup> eCalc reports NOx, SOx and CO2 emissions reduction from the US EPA eGRID database for power providers in the ERCOT region.

In 2009, IC3 developments included:

- A sister product, AIM was created for the State Comptroller's office.
- Usage statistics continue to climb.
- Updated to v3.6 which included 3 story houses, external cladding, more sophisticated ceiling/roof models, enhanced foundation modeling and the ability to copy projects

In 2010 there were several software updates including:

- IC3
  - 3.9.0 – Slab Insulation Support
  - 3.7.0 – 3.8.0 First Version of Multifamily Released along with numerous tweaks and fixes
  - 3.6.2 – New Building Model Integrated, Updated Artwork and Illustrations
- DDP
  - 1.7.05 – Added Heat Reject Recording for Electric and Gas
- Web Reports and Texas Building Registry
  - Registry 0.x – First versions of the Web Reports on TCV, eCalc, and IC3
  - Registry 1.0 – City and County Reports
  - Registry 1.1 – Cross-linked Reports for City and County
  - IC3 Reports 1.0 – Updated Certificate Reports which replace Registry 1.1 and evolve into the Texas Building Registry

The 2011 software updates include:

- IC3
  - 3.9.4 – Added approval workflow to start a new 2009 IECC job as further refinements were needed to the BDL
  - 3.9.5 – Various IECC 2009 fixes and refinements implemented
  - 3.9.6 – Updated BDL to 4.01.08, SHGC max does not apply to Climate Zone 4, 0.35 ACH minimum to all projects, Ventilation Fans added to % Air Conditioning Calculation
  - 3.9.7 - Corrected Certificate and Status screens to reflect insulation and floor construction.
  - 3.9.8- Set minimum R-value for insulated sheathing to R-2;
  - 3.10.0 - Updated and corrected problems with several text and value fields; Corrected and printed MF and SF Certificates;
  - 3.10.3 - Changed Certificate to Energy Audit Report; Added a new Certificate to be printed out; Added Inspector's list for a project; Added Pagination in projects page
  - 3.11.0 12/22/2011-Added Austin Energy 2009 IECC Energy Code Support
- Web Reports and Texas Building Registry
  - TBR Reports 1.0.5 – Added 4 new reports
  - TBR Reports 1.0.6 – Added 9 new reports
  - Registry 2.0 – Included 7 new Parameterized reports

The 2012 software updates include:

- IC3
  - 3.12 – Deprecated the 2000/2001 and 2006 Code (as of 1/1/2012)
  - 3.12.1 – Added a version of the energy report with a signature line, as requested by some municipalities. Improved the algorithm.
  - 3.12.2 – Alter help text to be more clear. Improved the algorithm.
  - 3.12.3 – Alter help pictures to make them clearer.

- 3.12.4 – Added optional input for water heaters to allow for better detail. Updated user manual. Improved the transform algorithms.

## 1.8 IC3 Texas Building Registry (TBR)

### 1.8.1 Background

In 2008, the 81<sup>st</sup> Texas Legislature amended the Texas Administrative Code (TAC .§388.008, 2009) to develop a Registry of Above-Code homes. The Laboratory built the first version of the Registry in 2009. This preliminary version allowed The Laboratory to provide basic metrics on usage of the Laboratory's above code calculators, *IC3*<sup>5</sup> and *TCV*<sup>6</sup>. By running reports against the calculator's databases, The Laboratory could determine calculator usage by month for Texas' Cities and Counties. These reports allowed a better understanding of how builders were adopting the calculators across the State so the Laboratory could improve the calculators.

Figure 3 shows the Projects and Certificates issued each month since January 2012. A Project is a house plan, while Certificates are printed reports given to the building official - assuming that the house is at or above code. In 2012, some users entered a basic floor plan and re-cycled it to generate more certificates. Figure 4 shows that more projects were entered (and presumably did not pass) than certificates created.

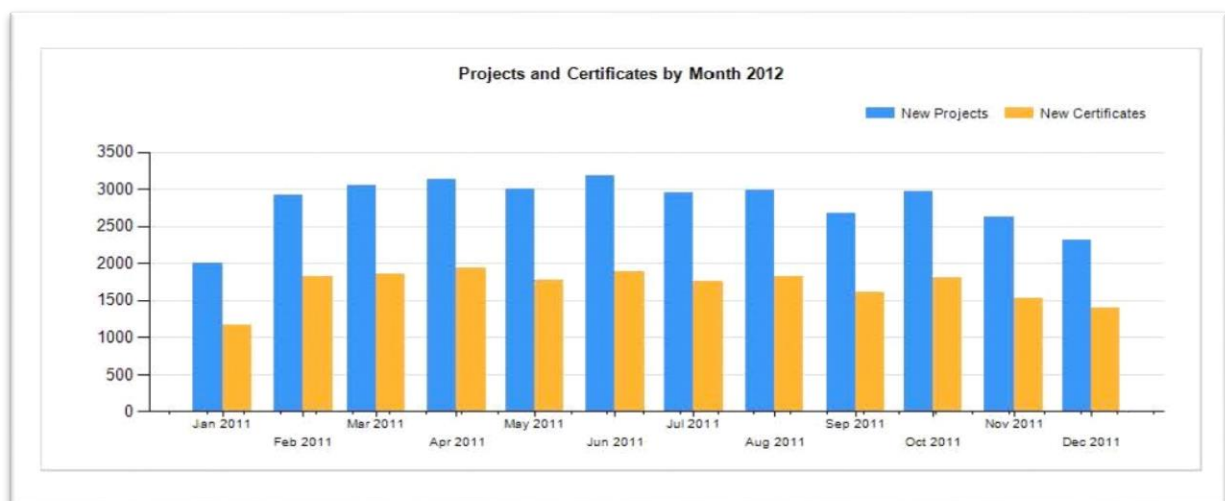


Figure 3: *IC3* 2012 Certificates and Projects

Figure 4: *IC3* 2012 Users vs. Certificates shows the cumulative Users and Certificates for 2012. The divergence between the two lines emphasizes the difference between the projects completed and certificates issued.

<sup>5</sup> International Code Compliance Calculator, a web based, above code calculator for single family, detached, new construction in Texas.

<sup>6</sup> Texas Climate Vision, a web based, above code calculator for single family, detached, new construction in Austin Energy's service area.



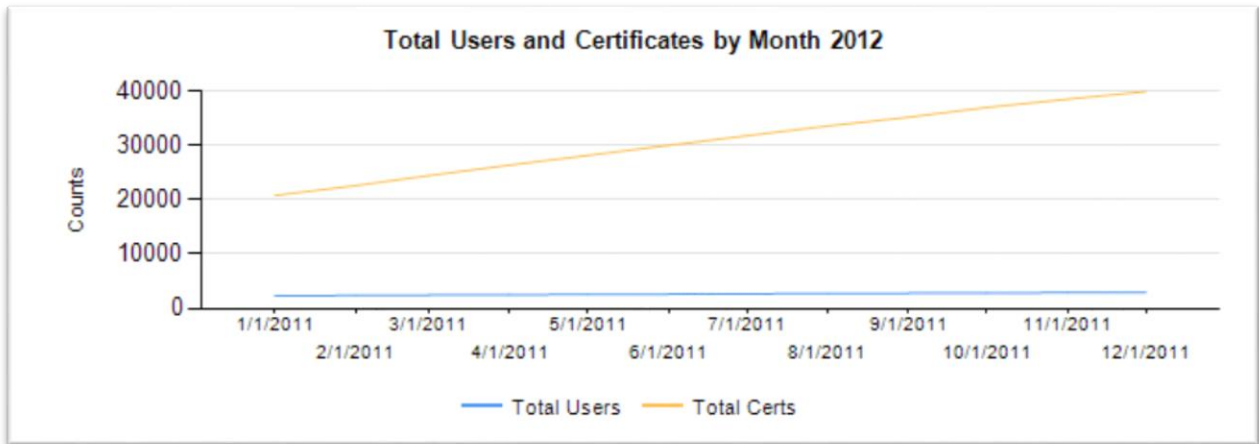


Figure 4: IC3 2012 Users vs. Certificates

Figure 5 shows that the largest adopter of the IC3 software was the North Central Texas Council of Governments (NCTCOG) area, specifically, users building in Dallas, Collin, Denton, and Tarrant Counties.

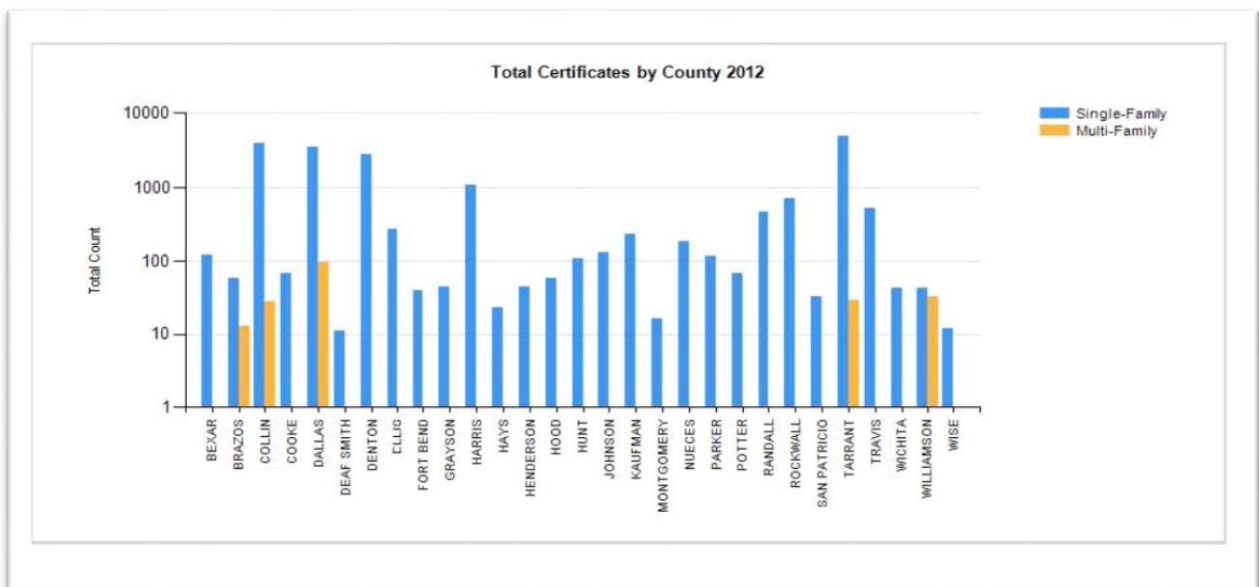


Figure 5: IC3 2012 Certificates – Counties with at least 10 Certificates

Figure 6 shows the certifications issued by city.

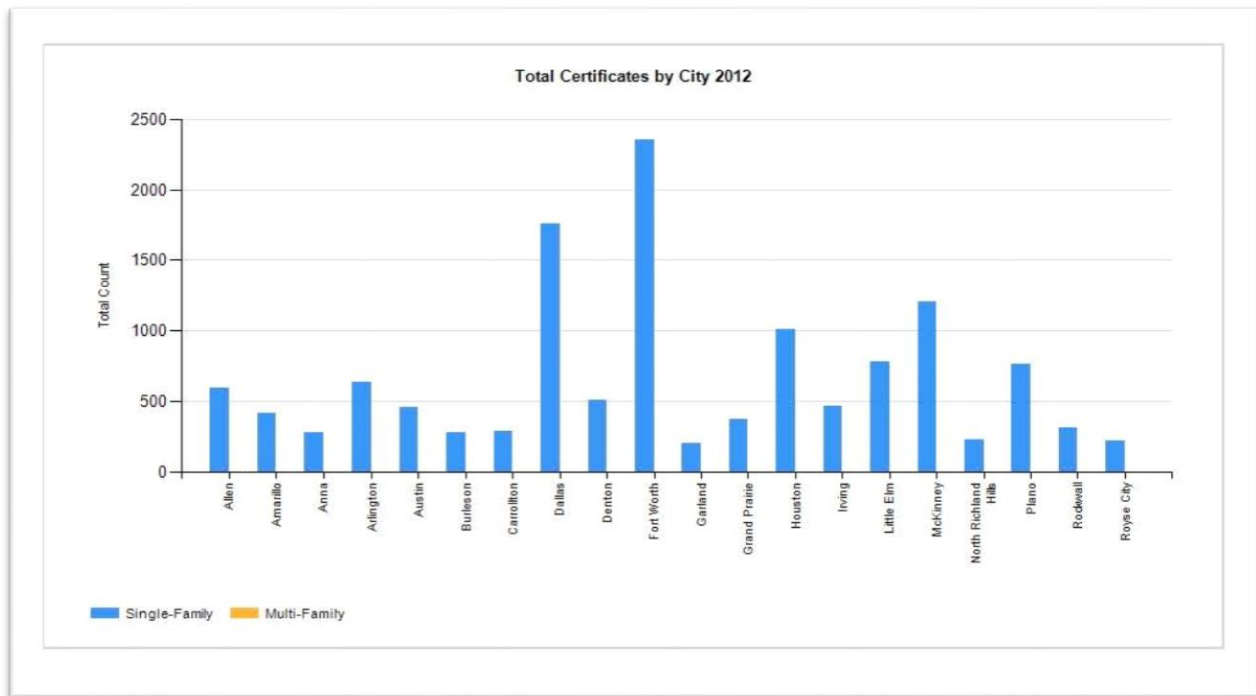


Figure 6: IC3 2012 Certificates – Cities with at least 200 Certificates

### 1.8.2 TBR Current Version

As illustrated below and a “*Report on the Development of the Format for a Texas Residential Registry* (Gilman, et al., 2008), the underlying database was optimized for supporting the IC3 and TCV calculators and therefore needed a transformation to allow for seamless reporting. Consequently, The Laboratory has been steadily adding reporting capability and has been making software changes to reflect the new reporting requirements and analysis capabilities. The underlying technology of the IC3 and TCV calculators is *Microsoft SQL Server 2008*. This product offers reporting capabilities through various tools.

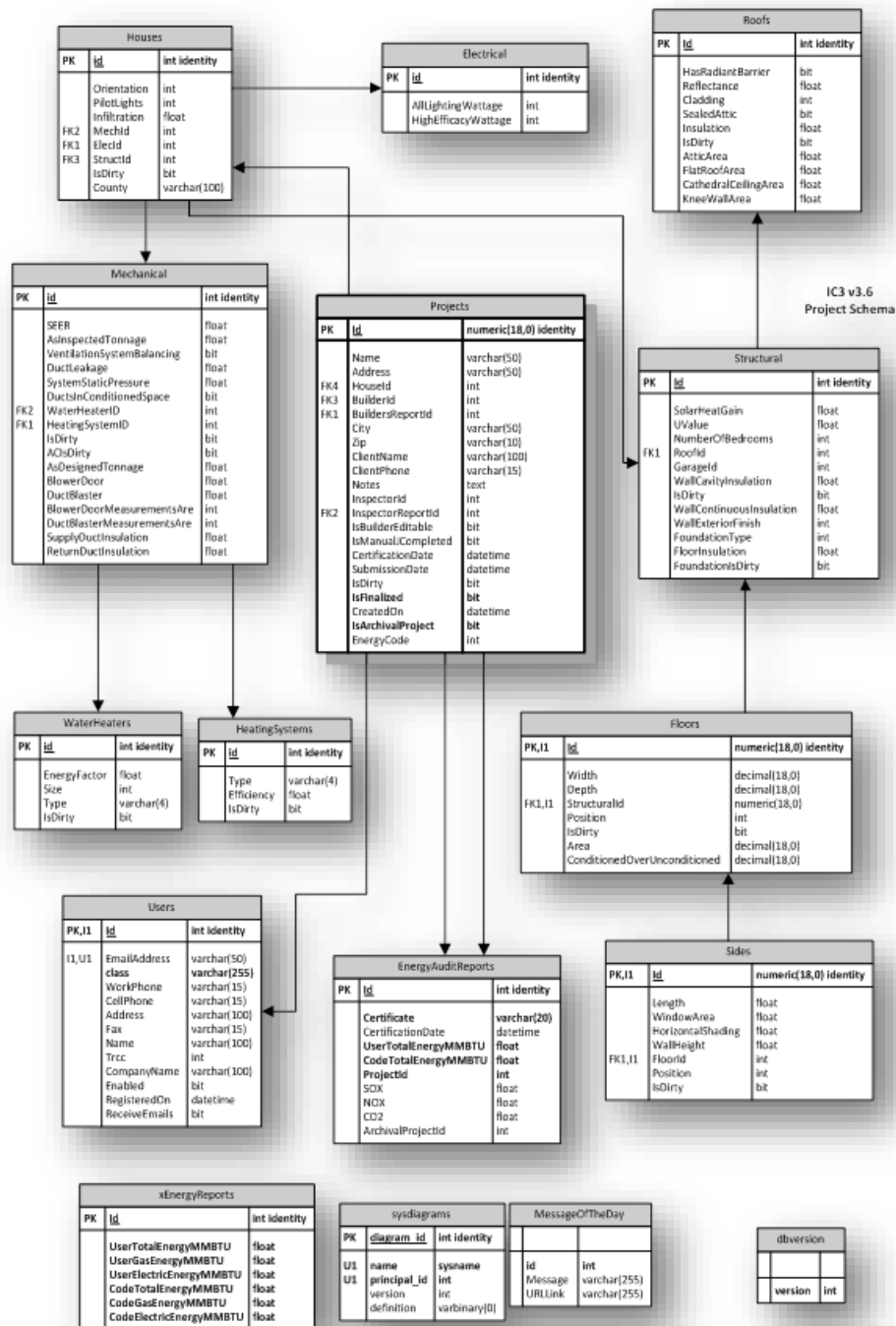


Figure 7: Database Schema

Figure 7: Database Schema shows the “layout” of the IC3 (v3.x) and TCV<sup>7</sup> (v1.1) databases. It gives a rough overview of the different tables (called “entities”) found in the IC3 database. The center entity is the Project, which

<sup>7</sup> The TCV v1.1 database has different fields due to the built-in inspection module and the fact it was completed two years earlier than the described IC3 v3.6.

is the center of the *IC3* software's abstraction of a house. The other tables include floors, walls, electrical, and systems.

### 1.8.3 Usage Reports

Figure 8 shows a steady growth from the start of record keeping (July 2009) until the end of 2012. During this year, ESL conducted several workshops and was able to detect a correlation between workshops and *IC3* usage.

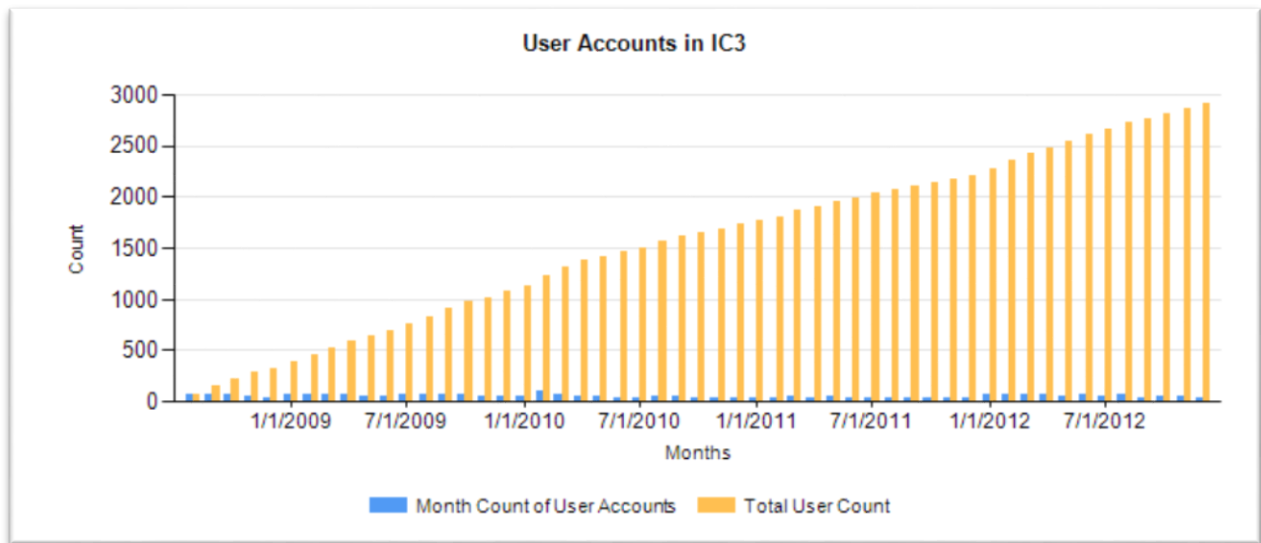


Figure 8: IC3 Usage Growth in 2012

Figure 9 shows the correlation between users and their successful projects (i.e. those that generate certificates). The graph shows that users were generating more certificates, and were doing so at a much faster rate than the rate of adding new users.

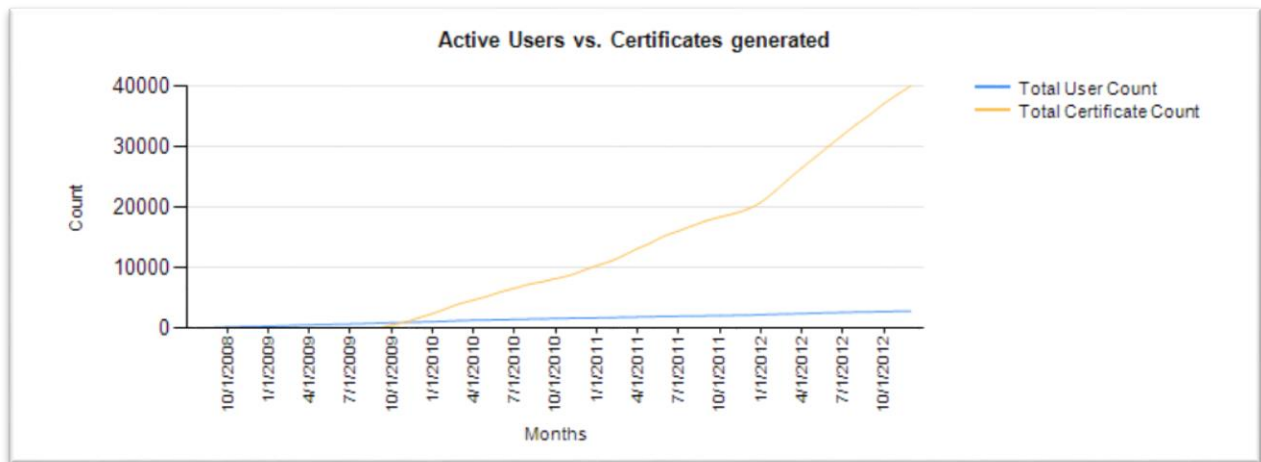


Figure 9: Users and Certificates 2012

Figure 10 through Figure 14 show where the usage was using Counties and Cities as the grouping entity. The North Central Texas Council of Governments (NCTCOG) led the way in usage during 2012.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ANDERSON	0	1	0	0	0	0	0	0	0	0	0	0	1
ANDREWS	0	0	0	0	0	0	0	0	0	2	0	0	2
BANDERA	0	0	0	2	0	0	0	0	0	0	0	0	2
BELL	0	0	4	0	0	3	0	0	0	0	0	0	7
BEXAR	0	2	8	7	8	8	17	9	6	19	8	26	119
BRAZORIA	0	0	0	0	0	3	0	0	0	0	0	0	3
BRAZOS	11	2	0	4	0	2	3	0	21	2	4	8	57
CARSON	0	0	0	0	0	0	0	0	1	0	0	0	1
COLLIN	187	358	330	396	372	404	319	328	327	366	268	295	3950
COLLINGSWORTH	0	0	1	0	0	0	0	0	0	0	0	0	1
COMAL	0	0	0	0	5	0	0	0	0	0	0	0	5
COOKE	0	0	14	17	6	7	2	6	8	2	0	5	67
DALLAS	222	328	353	368	296	311	367	316	299	285	261	198	3604
DEAF SMITH	0	0	0	0	4	0	3	0	0	3	1	0	11
DENTON	147	214	317	229	290	160	271	262	200	265	215	228	2798
ELLIS	18	41	34	21	29	31	11	33	18	25	10	10	279
FORT BEND	0	0	6	4	0	2	2	11	6	4	5	0	39
GALVESTON	1	0	2	3	0	0	0	0	0	0	0	0	6
GRAY	0	0	0	0	0	0	0	0	0	0	0	1	1
GRAYSON	4	2	0	7	1	1	0	7	5	7	5	5	45
HARRIS	46	75	41	118	93	129	69	123	69	102	122	101	1088
HAYS	0	14	0	0	1	1	6	0	0	0	0	1	23
HENDERSON	0	4	5	3	0	5	4	0	2	16	5	1	45
HOOD	7	3	2	5	8	6	6	0	3	7	2	9	58
HOUSTON	2	0	0	0	0	0	0	0	0	0	0	0	2
HUNT	16	27	7	8	6	19	11	6	3	3	1	0	107
HUTCHINSON	0	0	0	0	0	0	0	0	0	0	1	0	1
JOHNSON	6	8	16	9	7	11	11	14	18	6	16	8	128
KAUFMAN	7	12	22	30	48	29	10	15	33	6	13	8	233
KIMBLE	0	0	1	0	0	0	0	0	0	0	0	0	1
LIBERTY	0	0	0	0	0	0	0	0	0	0	1	1	2
LUBBOCK	0	0	0	0	0	0	0	0	2	3	0	0	5
MCLENNAN	0	0	0	0	0	0	0	0	0	2	0	0	2
MONTGOMERY	0	6	3	0	0	1	0	1	0	3	0	2	16
NUECES	12	11	29	28	20	12	12	11	12	13	14	10	184
OCHILTREE	0	0	0	0	0	0	0	0	1	0	0	0	1
PALO PINTO	0	0	0	0	0	0	0	0	0	0	2	0	2
PARKER	9	12	12	9	9	12	9	15	6	16	2	5	116
POTTER	2	3	0	2	11	12	9	6	12	4	0	7	68
RAINS	0	0	0	0	0	1	0	0	0	0	0	0	1
RANDALL	34	105	49	37	24	36	23	16	20	33	48	43	468
ROCKWALL	17	47	65	59	51	78	70	109	48	43	69	49	705
SAN PATRICIO	3	3	2	8	0	4	1	0	3	4	2	3	33
SCURRY	0	0	0	0	0	0	0	0	1	0	0	0	1
SMITH	0	0	0	0	0	0	0	0	0	1	0	0	1
TARRANT	345	392	460	438	425	564	452	443	367	419	359	288	4892
TAYLOR	0	0	0	0	0	0	0	2	2	1	0	0	5
TRAVIS	10	91	38	65	7	56	20	47	58	46	61	13	513
TYLER	0	0	0	0	0	0	0	2	0	0	0	0	2
VAN ZANDT	0	0	1	0	0	0	0	0	0	0	0	0	1
WALKER	0	0	3	0	2	0	0	0	0	0	0	0	5
WASHINGTON	3	0	0	0	0	0	0	0	0	0	0	0	3
WICHITA	11	6	1	2	3	1	3	2	6	2	0	8	42
WILLIAMSON	0	2	0	17	8	1	6	0	1	1	0	5	42
WISE	0	4	0	0	0	0	0	0	0	1	3	4	12
WOOD	0	0	0	1	0	0	0	0	0	0	0	0	1
YOUNG	0	2	0	0	0	0	0	0	0	0	0	0	2

Figure 10: Counties Generating Single Family IC3 Certificates in 2012

Counties Generating Multi-Family IC3 Certificates in 2012													
	Jan	Feb	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
BRAZOS	0	0	0	0	4	1	2	0	2	0	3	1	13
CASTRO	0	0	0	0	0	0	0	4	0	0	0	0	4
COLLIN	0	0	0	0	1	0	25	1	0	1	0	0	28
DALLAS	42	0	6	13	5	0	0	3	11	0	4	12	96
DENTON	0	0	3	0	0	0	0	0	0	0	0	0	3
GRAYSON	0	0	0	0	0	0	0	3	0	0	0	0	3
HARRIS	0	0	1	0	0	0	3	0	0	0	0	0	4
HOOD	0	0	0	0	0	7	0	0	0	0	0	0	7
RANDALL	0	0	0	0	0	0	0	0	6	0	1	0	7
TARRANT	0	0	1	5	7	4	0	1	6	2	3	0	29
TRAVIS	0	0	0	0	0	0	0	0	2	1	1	1	5
WILLIAMSON	0	11	0	0	0	0	0	0	4	0	0	17	32

Figure 11: Counties Generating Multi-Family IC3 Certificates in 2012



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dallas	0	1	2	0	0	0	0	0	0	0	0	0	3
Fort Worth	0	1	0	0	0	0	0	0	0	0	0	0	1
Houston	0	0	0	0	0	0	0	0	0	2	0	0	2
Irving	4	0	1	0	0	0	0	0	0	0	0	0	5
Irving	0	0	0	1	0	1	0	0	0	0	0	0	2
Abilene	0	0	0	0	0	0	0	0	2	0	0	0	2
Abilene	0	0	0	0	0	0	0	2	0	1	0	0	3
Addison	1	0	0	2	0	0	0	0	0	0	0	0	3
Aledo	0	0	2	4	0	2	0	0	2	3	0	0	13
Allen	35	64	46	62	41	41	29	34	60	99	73	21	694
Alvarado	0	0	0	0	0	3	0	0	0	0	0	0	3
Amarillo	27	83	30	25	31	40	30	19	30	27	38	40	419
Andrews	0	0	0	0	0	0	0	0	0	2	0	0	2
Anna	3	18	13	17	22	43	18	30	24	36	21	31	276
Argyle	0	0	1	0	1	0	0	2	2	7	4	2	19
Arlington	18	19	31	53	40	82	89	85	67	50	53	51	638
Athens	0	0	3	0	0	0	0	0	0	0	0	0	3
Aubrey	0	14	4	15	16	4	25	0	0	0	0	0	78
Aubrey	0	0	0	0	0	0	0	0	0	0	14	7	21
Austin	7	88	19	59	6	54	17	44	51	42	58	12	457
Autin	0	0	0	0	0	0	0	0	2	0	3	0	5
Azle	0	0	0	0	3	0	0	0	0	4	2	1	10
Balch Springs	1	3	0	0	0	9	0	5	0	1	0	0	19
Bandera	0	0	0	2	0	0	0	0	0	0	0	0	2
Bartonville	0	0	0	0	0	0	0	0	2	0	0	0	2
BAYTOWN	0	0	0	1	0	0	0	0	0	0	0	0	1
Bedford	0	0	0	0	0	0	0	1	1	0	0	0	2
Bellaire	6	0	0	1	1	0	0	2	0	0	0	1	11
Benbrook	10	4	30	21	7	2	10	12	11	4	2	12	125
Brenham	3	0	0	0	0	0	0	0	0	0	0	0	3
Bryan	0	0	0	0	0	0	0	0	0	0	0	3	3
Burleson	16	19	32	28	21	27	13	41	33	18	22	10	280
Burleston	0	0	0	1	1	0	0	0	0	0	0	0	2
Burlington	0	0	0	0	0	4	0	0	0	0	0	0	4
Bushland	0	0	0	0	0	0	1	1	0	0	0	0	2
Canyon	9	25	19	14	4	9	1	3	2	10	11	10	117
Carrollton	13	33	37	23	27	16	15	34	31	30	19	10	288
Carrollton	0	1	8	14	4	2	2	3	0	0	0	0	34
CEDAR HILL	1	0	0	3	5	6	0	3	0	0	1	0	19
Cedar Hill	0	0	7	0	0	0	1	0	0	0	0	2	10
Cedar Hills	0	0	0	0	0	0	0	0	0	0	2	1	3
CEDARHILL	0	0	0	0	2	1	0	1	1	0	0	0	5
Celina	4	25	1	3	7	16	0	6	4	5	1	2	74
Chandler	0	0	0	0	0	0	0	0	0	0	3	0	3
Chapel Hill	0	0	0	0	2	0	0	0	0	3	0	0	5
Cochrill Hill	0	0	0	0	0	0	0	0	1	0	0	0	1
College Station	11	2	0	4	0	2	3	0	21	2	4	5	54
Colleyville	14	5	13	11	15	27	11	7	7	9	9	7	135
Conroe	0	0	0	0	0	0	0	0	0	0	5	0	5
Copeville	0	0	0	0	0	4	0	0	0	0	0	0	4
Coppell	2	7	19	12	4	5	5	4	2	4	8	2	75
Copper Canyon	0	0	0	0	0	0	0	0	0	0	0	1	1

Figure 12: Cities Generating Single Family IC3 Certificates in 2012



Corinth	5	2	6	1	1	0	3	0	0	0	0	0	18
Corpus Christi	12	11	29	28	20	12	12	11	12	13	14	10	184
Crandall	0	15	7	22	28	1	1	9	4	0	4	3	94
Crandell	2	0	1	0	3	0	0	0	0	0	0	0	6
Cross Roads	0	0	1	1	0	1	0	45	1	0	0	0	49
Cross Roads	0	0	0	0	0	0	10	0	0	0	0	0	10
Crossroads	0	0	0	0	0	0	0	0	0	0	0	2	2
Crowley	4	10	3	2	11	3	6	8	2	3	4	12	68
Cypress	0	0	0	0	0	0	0	2	0	1	0	0	3
Dallas	159	158	214	156	151	141	190	0	114	129	131	87	1630
Dallas	0	0	0	0	0	0	0	132	0	0	0	0	132
Dallas	0	0	0	0	0	3	0	0	0	0	0	0	3
Dalworthington Gardens	0	0	1	0	0	0	0	1	0	1	0	0	3
Dayton	0	0	0	0	0	0	0	0	0	0	1	1	2
Denison	4	2	0	0	0	0	0	0	0	0	2	0	8
Denton	14	23	74	47	77	16	31	64	28	55	34	43	506
DeSoto	7	3	1	3	5	6	9	21	13	1	0	8	77
Dish	0	4	0	0	0	0	0	0	0	0	0	0	4
Double Oak	0	0	0	0	0	0	0	0	0	5	0	1	6
Dripping Springs	0	0	0	0	0	0	2	0	0	0	0	0	2
Duncancille	0	0	0	0	0	0	0	0	1	0	0	0	1
Duncancville	0	0	1	0	0	0	0	0	0	0	0	0	1
Duncanville	3	0	5	1	3	1	0	1	0	0	8	5	27
Ennis	0	0	0	1	0	0	0	0	0	0	0	0	1
Eules	0	10	1	3	6	18	7	0	6	7	1	0	59
Fairview	0	23	2	0	2	17	5	4	1	0	10	3	67
Fairview	2	0	0	0	0	0	0	0	0	0	0	0	2
Farmers Branch	0	0	0	9	5	0	0	1	0	1	0	0	16
Fate	1	9	30	10	16	18	14	26	15	9	9	11	168
Flower Mound	17	17	16	9	16	26	21	5	13	13	7	34	194
Flowermound	0	0	0	0	0	0	0	3	0	0	0	2	5
Flowermound	0	0	0	0	0	0	0	0	2	0	0	0	2
Foreny	0	0	0	0	0	0	0	0	1	0	0	0	1
Forest Hill	0	0	0	0	0	0	3	0	0	0	0	0	3
Forney	3	2	6	13	9	17	12	9	34	12	9	7	133
Forrest Hill	0	0	0	0	0	3	0	0	0	0	0	0	3
Fort Worth	198	226	228	199	203	223	193	188	150	218	194	138	2358
FORTWORTH	0	0	0	0	4	0	0	7	0	0	0	0	11
Friendswood	0	0	2	0	0	0	0	0	0	0	0	0	2
Frisco	0	4	24	11	2	1	5	7	3	1	2	9	69
Ft Worth	7	1	0	0	11	25	0	6	27	0	30	20	127
Ft Worth	0	0	7	8	0	0	39	0	0	19	0	0	73
Ft. Worth	0	3	6	0	0	1	2	0	0	0	0	1	13
Gainesville	0	0	14	17	6	7	1	6	9	2	0	4	66
Gainseville	0	0	0	0	0	0	0	0	0	0	0	1	1
Gainsville	0	0	0	0	0	0	1	0	0	0	0	0	1
Galveston	0	0	0	3	0	0	0	0	0	0	0	0	3
garden ridge	0	0	0	0	5	0	0	0	0	0	0	0	5
Garland	0	15	14	0	31	19	0	21	3	11	24	9	147
Garland	11	0	0	23	0	0	21	0	0	0	0	0	55
Glenn Heights	0	0	0	0	0	0	0	0	0	0	0	2	2
Godley	0	0	0	0	0	0	1	0	0	0	0	0	1
Graford	0	0	0	0	0	0	0	0	0	0	2	0	2
Graham	0	2	0	0	0	0	0	0	0	0	0	0	2
Granbury	7	3	2	5	8	6	9	0	3	2	2	9	56
Grand Prairie	0	0	0	0	0	0	2	0	0	0	0	0	2
Grand Prairie	10	44	33	35	46	32	24	0	33	36	30	10	333
Grand Prairie	0	0	0	0	0	0	0	37	0	0	0	0	37
Grand Prairie	0	0	0	0	0	0	0	0	0	2	0	0	2
Grandbury	0	0	0	0	0	0	0	1	0	5	0	0	6
Grapevine	2	11	2	1	1	4	7	3	9	0	2	6	47

Figure 12: Cities Generating Single Family IC3 Certificates in 2012 (continued)

Greenville	1	2	1	0	0	1	9	2	0	0	1	0	17
Gun Barrel City	0	0	2	3	0	5	1	0	1	15	3	1	31
Gunter	0	0	0	0	0	0	0	0	0	4	0	0	4
Gunter	0	0	0	0	0	1	0	0	0	0	0	0	1
Hackberry	4	5	0	5	8	6	16	4	6	0	1	0	55
Harker Heights	0	0	4	0	0	0	0	0	0	0	0	0	4
Haslet	1	4	2	3	2	6	3	2	0	6	2	2	33
Haslett, TX	0	3	0	0	0	0	0	0	0	0	0	0	3
Health	0	0	0	0	0	1	0	0	0	0	0	0	1
Heartland	0	1	3	2	4	1	0	0	0	0	0	0	11
Heath	3	2	6	9	11	4	12	6	5	5	8	8	79
Helotes	0	0	0	0	0	0	0	0	0	1	0	0	1
Hereford	0	0	0	0	4	0	3	0	0	3	1	0	11
Hewitt	0	0	0	0	0	0	0	0	0	0	1	0	1
Hickory Creek	0	0	0	0	0	0	0	0	0	0	2	0	2
Highland Park	4	5	3	3	4	3	13	10	1	4	8	5	63
Highland Village	0	2	5	0	1	2	0	0	3	0	1	2	16
Houston	43	66	37	110	90	122	67	115	68	95	101	97	1011
Houston, TX	0	0	0	0	0	0	0	0	0	2	0	0	2
Hudson Oaks	0	6	0	4	6	6	6	2	5	1	3	3	45
Huffman	0	4	0	0	1	0	0	0	0	1	0	0	6
humble	0	1	0	5	0	1	1	0	0	0	0	0	8
Hurst	1	0	0	3	0	1	0	2	0	1	0	0	8
Hurst	0	0	0	0	2	0	0	0	0	0	0	0	2
Irving	6	35	58	53	29	39	37	55	56	54	24	21	467
Jarrell	0	2	0	0	0	0	0	0	0	1	0	0	3
Josephine	2	4	3	1	8	8	0	2	1	0	1	1	31
Josephine	1	2	3	0	2	7	0	0	0	0	0	0	15
Joshua	0	0	0	0	0	0	2	0	0	0	3	0	5
Justin	0	0	0	0	0	0	0	1	0	0	0	0	1
Katy	0	0	0	0	0	0	0	1	0	0	4	5	10
Kaufman	1	0	5	0	7	6	2	0	0	0	0	0	21
Keller	0	10	7	19	12	16	8	4	10	11	12	4	113
Kennedale	0	0	0	0	0	1	0	0	2	0	0	0	3
Kingswood	0	0	2	0	0	0	0	0	0	0	0	0	2
Kingwood	0	5	2	1	0	1	1	3	4	3	4	1	26
Krum	2	7	6	2	2	3	6	5	4	6	7	18	68
La Porte	0	0	0	0	0	3	0	0	0	0	0	0	3
Lake Dallas	0	0	0	0	0	0	0	0	0	1	0	0	1
Lakewood Village	0	0	0	8	0	0	0	0	0	0	0	0	8
Lancaster	0	12	7	1	1	10	19	5	21	5	5	5	91
Lantana	0	0	3	0	1	5	3	1	4	1	2	0	20
Lavon	2	2	0	1	0	10	16	4	4	1	2	11	53
League City	1	0	0	0	0	0	0	0	0	0	0	0	1
Lewisville	4	8	2	5	14	6	15	19	15	14	38	0	140
Lewisville	0	0	0	0	0	0	0	0	0	0	0	10	10
Lexington	0	0	1	0	0	0	0	0	0	0	0	0	1
Little Elm	73	70	123	0	73	55	56	49	0	64	0	41	604
Little Elm	0	0	0	71	0	0	0	0	63	0	40	0	174
Lubbock	0	0	0	0	0	0	0	0	2	3	0	0	5
Lucas	8	7	3	6	3	9	12	13	7	8	6	13	95
Mabank	0	0	0	0	0	1	0	0	0	0	0	0	1
Malakoff	0	4	0	0	0	0	3	0	1	1	0	0	9
Mansfield	10	21	24	18	25	19	13	16	12	17	17	7	199
Manuel	0	0	0	0	0	2	0	0	0	0	0	0	2
MASTER	2	5	1	8	2	2	6	5	2	9	4	5	51
Mc Kinney	0	0	0	0	1	0	1	0	0	0	0	0	2
McKinney	52	81	100	145	123	139	110	97	96	111	82	67	1203
McLendon Chisholm	0	0	0	0	0	0	0	0	0	1	1	0	2
McLendon-Chisholm	0	0	0	0	0	0	0	0	1	2	0	4	7
Melissa	17	31	18	13	26	26	11	12	14	4	8	19	199

Figure 12: Cities Generating Single Family IC3 Certificates in 2012 (continued)



Mesquite	0	9	0	0	4	5	2	3	13	7	8	0	51
Midlothian	0	1	0	0	0	2	0	0	0	0	0	0	3
Midlothian	9	9	15	5	10	15	1	9	14	23	7	2	119
Missouri City	0	0	0	0	0	0	1	7	4	3	2	0	17
Moore	0	0	0	0	0	0	2	0	0	0	0	0	2
Murphy	2	3	2	2	3	1	1	2	2	3	2	30	53
N Richland Hills	0	0	3	0	0	0	0	0	0	0	1	0	4
N. Richland Hills	0	0	1	5	1	2	0	1	0	1	2	0	14
New Hope	0	0	0	1	0	0	0	0	0	0	0	0	1
North Lake	0	0	0	0	0	0	0	0	4	0	0	0	4
North Richland Hills	34	15	18	16	28	12	20	17	17	31	10	11	229
not sure	0	1	0	0	0	0	0	0	0	0	0	0	1
NRH	0	0	0	0	0	0	1	0	0	0	0	0	1
Oak Point	0	0	0	4	9	2	0	6	6	8	8	1	44
Oak Pointe	0	0	0	0	0	0	3	0	0	3	1	0	7
Paloma Creek	0	0	0	0	0	3	0	0	0	0	0	0	3
Pampa	0	0	0	0	0	0	0	0	0	0	0	1	1
Panhandle	0	0	0	0	0	0	0	0	1	0	0	0	1
Pantego	0	0	0	0	0	5	4	0	0	0	0	2	11
Parker	0	0	2	0	0	3	0	1	1	0	2	1	10
Pasadena	0	0	0	0	0	0	0	0	0	0	3	0	3
Pearland	0	0	0	0	0	1	0	0	0	0	0	0	1
Perryton	0	0	0	0	0	0	0	0	1	0	0	0	1
Piney Point	0	0	0	0	0	2	0	0	0	0	0	0	2
Piano	42	44	85	88	92	47	66	74	73	63	36	54	764
Ponder	0	0	6	0	0	0	0	0	0	0	0	0	6
Portland	0	3	2	8	0	0	0	0	3	4	2	3	25
Portland	3	0	0	0	0	4	1	0	0	0	0	0	8
Princeton	10	18	14	16	13	12	3	3	9	12	10	6	126
Princeton	0	0	0	0	0	1	0	0	0	0	0	0	1
Prosper	2	3	11	3	4	0	0	4	1	10	0	0	38
Providence	14	14	19	28	19	7	11	7	13	10	5	10	157
Quinlan	0	0	0	1	0	0	0	0	0	0	0	0	1
Red Oak	2	4	14	4	2	0	3	5	1	0	0	0	35
Rhome	0	0	0	0	0	0	0	0	0	0	2	0	2
Richardson	5	17	4	39	4	15	26	5	23	10	12	11	171
Roanoke	0	0	0	0	0	0	0	0	0	2	1	0	3
Roanoke	4	0	0	0	0	0	0	0	0	0	0	0	4
Rockwall	11	39	16	23	17	37	27	55	24	16	31	22	318
Rockwall County	0	0	0	0	0	1	0	0	0	0	0	0	1
Rockwall Tx.	0	0	0	0	0	1	0	0	0	0	0	0	1
Round Rock	0	0	0	0	8	1	0	0	0	0	0	6	15
Rowlett	0	5	0	0	2	7	13	14	0	10	1	8	60
Royce City	0	0	0	1	1	0	0	1	0	0	0	0	3
Royce City	0	0	0	0	0	0	1	0	0	0	3	1	5
Roy's City	0	0	0	0	0	0	0	0	0	2	0	0	2
Royse City	17	25	19	23	14	34	25	26	11	12	14	3	223
Runaway Bay	0	0	0	0	0	0	0	0	0	1	1	4	6
Sachse	0	6	2	3	5	7	8	4	5	5	0	0	45
Sachse	0	0	0	0	0	0	0	0	0	0	0	3	3

Figure 12: Cities Generating Single Family IC3 Certificates in 2012 (continued)

Saginaw	4	4	6	4	2	6	0	2	0	2	0	1	31
Salado	0	0	0	0	0	3	0	0	0	0	0	0	3
San Antonio	0	2	9	7	8	9	17	9	6	18	8	26	118
San Marcos	0	14	0	0	0	1	0	0	0	0	0	0	15
Sanger	0	0	0	1	4	4	4	0	2	6	2	7	30
Sansom Park	0	0	0	1	0	0	0	0	0	0	0	0	1
Savannah	1	10	4	12	10	0	9	1	2	16	8	12	84
Seagoville	0	0	0	0	0	1	0	0	0	0	0	0	1
Seagoville	2	7	4	1	3	14	0	6	3	1	0	6	47
Shady Shores	0	0	0	0	0	0	1	0	0	0	0	0	1
Shenandoah	0	0	0	0	0	0	0	0	0	3	0	2	5
Shendandoah	0	6	3	0	0	1	0	1	0	0	0	0	11
Sherman	0	0	0	0	0	0	0	7	0	0	0	0	7
Snyder	0	0	0	0	0	0	0	0	1	0	0	0	1
South Lake	0	0	0	0	0	0	0	1	0	4	0	0	5
South Lake	0	0	0	0	0	2	1	0	0	0	0	0	3
Southlake	19	2	22	27	14	13	15	17	21	17	15	12	194
Southlake, Tx.	0	0	2	0	0	0	0	0	0	0	0	0	2
Spring Valley	0	0	0	0	0	0	0	0	0	0	1	0	1
SUGAR LAND	0	0	0	0	0	0	0	0	0	0	1	0	1
Sugarland	0	0	6	2	0	2	1	4	1	1	2	0	19
Sunnyvale	2	2	1	0	0	1	3	1	0	0	0	1	11
Taylor	0	0	0	17	0	0	6	0	1	0	0	0	24
Terrell	2	0	0	1	0	0	0	2	1	1	2	0	9
The Colony	0	0	0	3	2	0	3	0	0	0	2	0	10
This is a test	0	0	0	1	0	0	0	0	0	0	0	0	1
Tioga	0	0	0	0	3	0	0	0	0	0	1	0	4
Trophy Club	1	28	29	13	22	11	42	24	5	11	5	6	197
Tyler	0	0	0	0	0	0	0	0	0	1	0	0	1
Univ Park	0	1	0	0	0	0	0	0	0	0	0	0	1
University Park	1	0	0	0	0	0	0	0	0	0	0	1	2
University Park	0	0	0	0	0	1	0	0	0	0	0	0	1
University Park	4	7	2	21	6	4	8	6	7	7	2	4	77
University Park	0	0	0	0	0	0	1	0	0	0	0	0	1
University Park	0	0	0	0	0	2	0	0	0	0	0	0	2
Van Alstyne	0	0	0	7	1	0	0	5	6	3	3	7	32
Venus	0	0	0	1	3	0	1	1	0	0	1	3	10
Waco	0	0	0	0	0	0	0	0	0	2	0	0	2
Waxachie	0	3	1	1	4	1	1	1	0	0	0	0	12
Waxahachie	5	18	8	2	9	4	5	13	3	2	3	6	78
Way	0	2	0	0	0	0	0	0	0	0	0	0	2
Weaferford	0	0	0	0	0	0	0	0	1	1	0	0	2
Weatherford	9	6	6	0	1	4	3	9	1	3	0	2	44
West Lake Hills	0	0	0	0	0	0	0	0	3	0	0	0	3
West University	0	0	0	0	1	0	0	0	0	0	3	0	4
West University Place	0	0	0	2	0	0	0	0	0	0	0	0	2
Westlake	1	4	1	0	0	0	0	6	0	0	0	0	12
Westlake	0	0	0	0	0	1	5	0	0	0	0	16	23
Westover Hills	1	0	0	0	0	0	0	1	0	0	0	0	2
Westworth	0	0	0	0	0	0	0	0	0	2	0	0	2
Westworth Village	0	0	0	0	0	0	0	0	0	0	0	2	2
Wichita Falls	11	6	1	2	3	1	3	2	6	2	0	5	42
Wills point	0	0	1	0	0	0	0	0	0	0	0	0	1
Wimberley	0	0	0	0	1	0	4	0	0	0	0	1	6
Winnsboro	0	0	0	1	0	0	0	0	0	0	0	0	1
Wylie	8	30	10	16	10	9	10	25	17	10	12	24	181

Figure 12: Cities Generating Single Family IC3 Certificates in 2012 (continued)

Cities Generating Multi-Family IC3 Certificates in 2012													
	Jan	Feb	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
	0	0	1	0	0	0	0	0	0	0	0	0	1
Allen	0	0	0	0	1	0	0	0	0	0	0	0	1
Austin	0	0	0	0	0	0	0	0	2	1	1	1	5
Bryan	0	0	0	0	3	0	1	0	0	0	2	1	7
canyon	0	0	0	0	0	0	0	0	6	0	1	0	7
College Station	0	0	0	0	1	1	1	0	2	0	1	0	6
Dallas	42	0	2	13	5	0	0	3	11	0	4	4	84
Denton	0	0	3	0	0	0	0	0	0	0	0	0	3
Dimmitt	0	0	0	0	0	0	0	4	0	0	0	0	4
Fort Worth	0	0	1	5	7	3	0	1	3	2	2	0	24
granbury	0	0	0	0	0	7	0	0	0	0	0	0	7
HOUSTON	0	0	0	0	0	0	3	0	0	0	0	0	3
Irving	0	0	4	0	0	0	0	0	0	0	0	4	8
Jarrell	0	11	0	0	0	0	0	0	0	0	0	0	11
Keller	0	0	0	0	0	1	0	0	3	0	1	0	5
McKinney	0	0	0	0	0	0	25	0	0	0	0	0	25
Plano	0	0	0	0	0	0	0	1	0	0	0	0	1
Richardson	0	0	0	0	0	0	0	0	0	0	0	4	4
Round Rock	0	0	0	0	0	0	0	0	4	0	0	17	21
Sherman	0	0	0	0	0	0	0	3	0	0	0	0	3
Wylie	0	0	0	0	0	0	0	0	0	1	0	0	1

Figure 13: Cities Generating Multi-Family IC3 Certificates in 2012

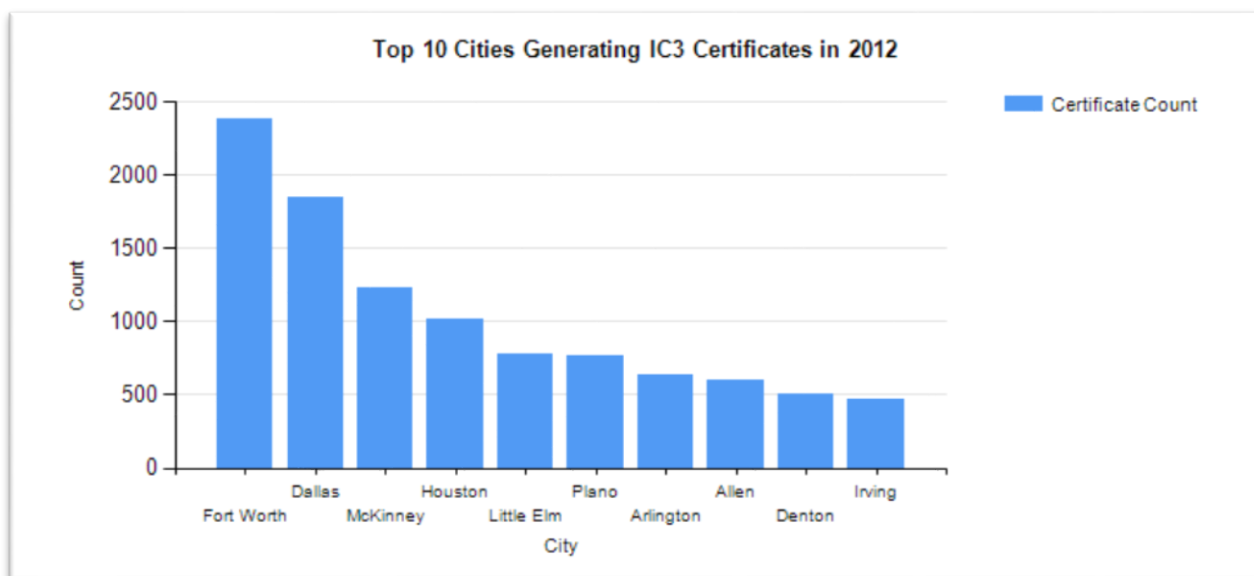


Figure 14: Top 10 Cities Generating Certificates in 2012

#### 1.8.4 Parameter Reports

A unique and valuable use of the Registry is to look at building trends across the state.



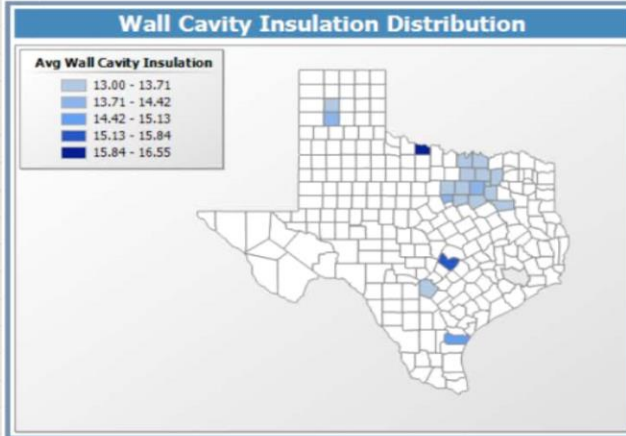
## Yearly Average Wall Cavity Insulation Distribution for 2012

Overall Data Statistics derived from a subset of Counties having house count > 10

	Total Count	Average Wall Cavity Insulation	Standard Deviation
Single Family	12637	13.76	1.91
Multi Family	472	17.03	2.44

### Single Family

County	Avg Wall Cavity	House Count
Harris	16.55	540
Wichita	15.97	29
Travis	15.68	187
San patricio	15.00	24
Nueces	14.98	120
Randall	14.16	301
Dallas	13.98	2219
Hood	13.91	38
Denton	13.69	1918
Cooke	13.61	28
Collin	13.56	2689
Johnson	13.52	68
Potter	13.49	55
Henderson	13.47	19
Tarrant	13.40	3247
Rockwall	13.35	475
Grayson	13.25	24
Fort bend	13.21	28
Bexar	13.19	78
Ellis	13.11	237
Parker	13.10	59
Hunt	13.06	64
Kaufman	13.00	190



### Multi Family

County	Avg Wall Cavity	Unit Count
Dallas	18.46	272
Williamson	15.41	175
Tarrant	12.68	25

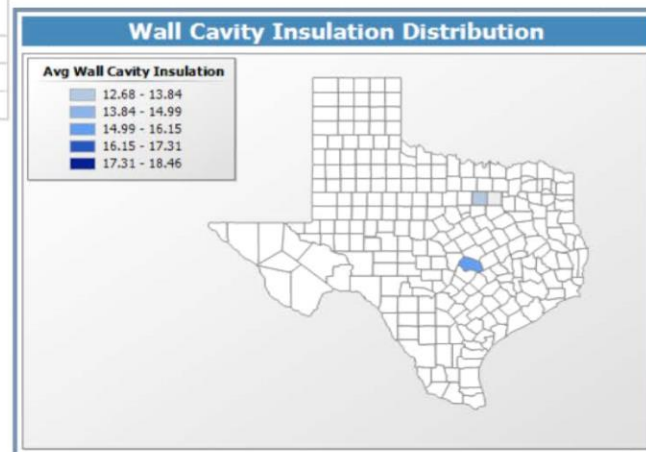


Figure 15: Average Wall Cavity Insulation by County 2012

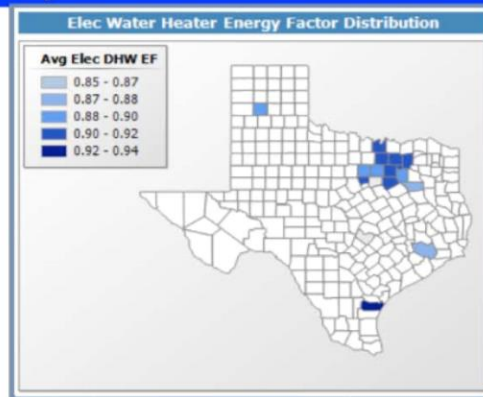
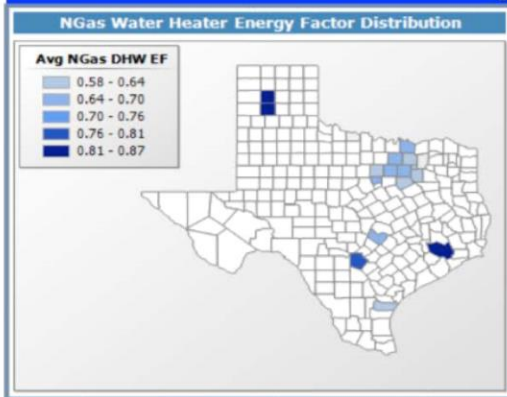
## Yearly Average Water Heater Energy Factor Distribution for 2012

Overall Data Statistics derived from a subset of Counties having house count > 10

	Total Count	Average NGas EF	Standard Deviation
Single Family	4242	0.90	0.05
Multi Family	73	0.85	0.11

	Total Count	Average Elec EF	Standard Deviation
Single Family	8429	0.67	0.12
Multi Family	190	0.93	0.03

### Single Family



County	Avg NGas WH EF	House Count
Wichita	0.87	19
Potter	0.87	49
Randall	0.83	95
Harris	0.83	529
Fort bend	0.82	28
Bexar	0.78	76
Dallas	0.69	1675
Travis	0.69	150
Hood	0.68	15
Grayson	0.68	23
Tarrant	0.66	1459
Denton	0.66	1187
Collin	0.62	2271
Parker	0.62	23
Rockwall	0.61	399
Ellis	0.60	133
Nueces	0.58	92
Kaufman	0.58	145
Hunt	0.58	21

County	Avg Elec WH EF	House Count
Travis	0.94	37
San patricio	0.93	24
Nueces	0.93	28
Hood	0.92	23
Cooke	0.92	26
Hunt	0.91	43
Rockwall	0.91	76
Denton	0.91	731
Ellis	0.91	104
Dallas	0.90	544
Collin	0.90	418
Parker	0.90	36
Tarrant	0.90	1788
Randall	0.89	206
Kaufman	0.89	45
Harris	0.88	11
Henderson	0.88	15
Johnson	0.85	59

Figure 16: Average Water Heater Efficiencies 2012

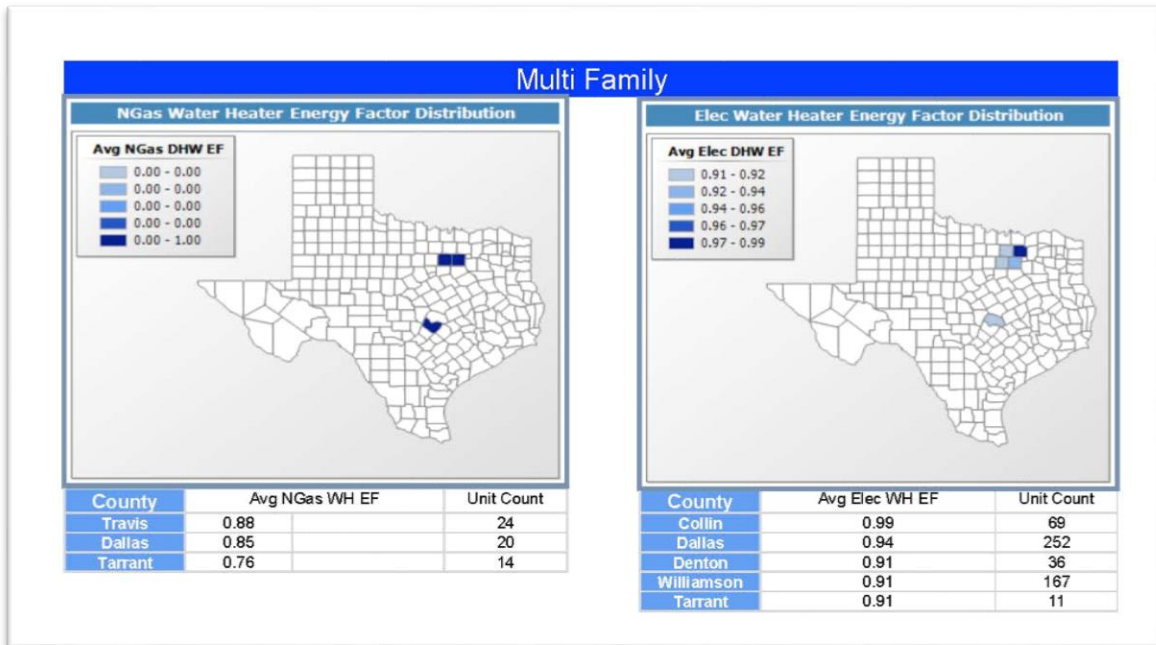


Figure 16: Average Water heater Efficiencies 2012 (continued)

This report shows both natural gas and electric water heater efficiencies across Texas in 2012.



### Average Window to Wall Area Ratio across Counties for 2012

Overall data Statistics derived from a subset of Counties having house count > 10

	Average	Standard Deviation
Single Family	11.46	3.68
Multi Family	15.18	6.71

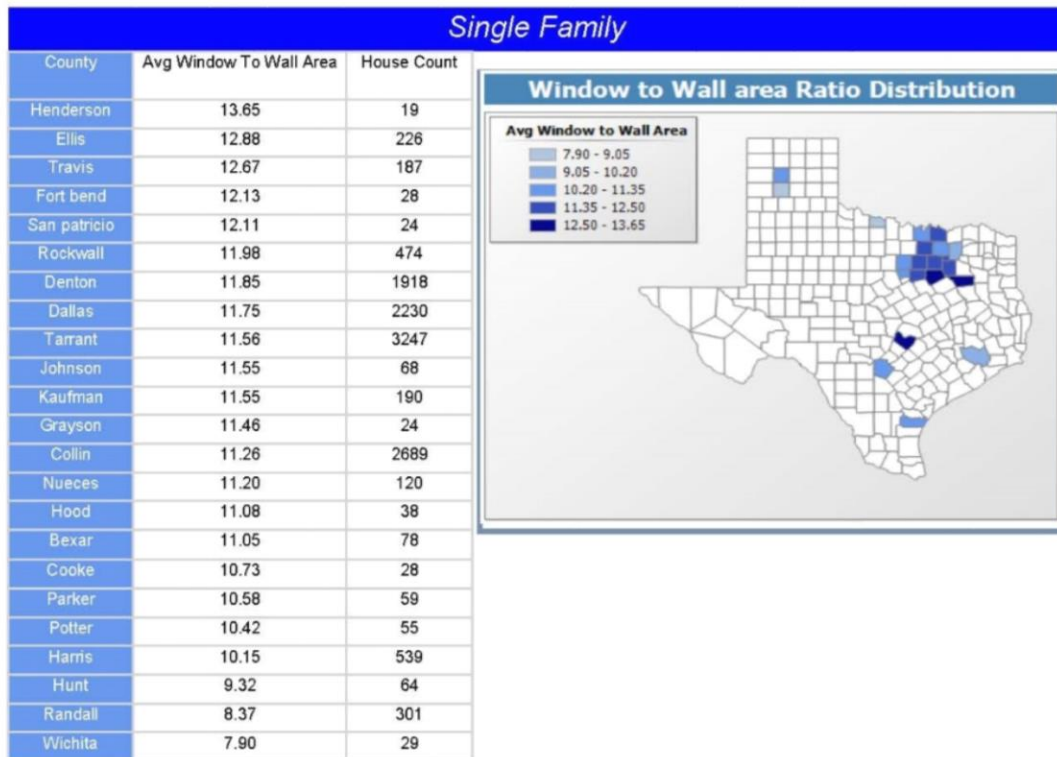


Figure 17: Average Window to Wall Ratio 2012

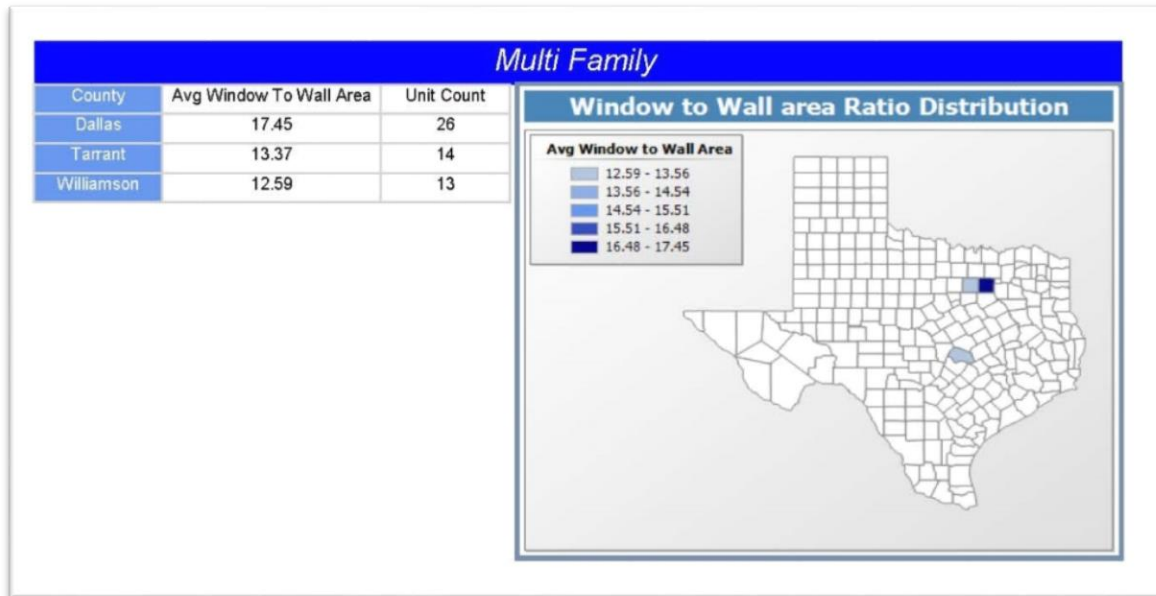


Figure 17: Average Window to Wall Ratio 2012 (continued)

Here is an analysis of the window to wall ratio across Texas in 2012.

The formula used is:  $100 * \frac{\text{total window area sq. ft.}}{\text{total wall area sq. ft.}}$

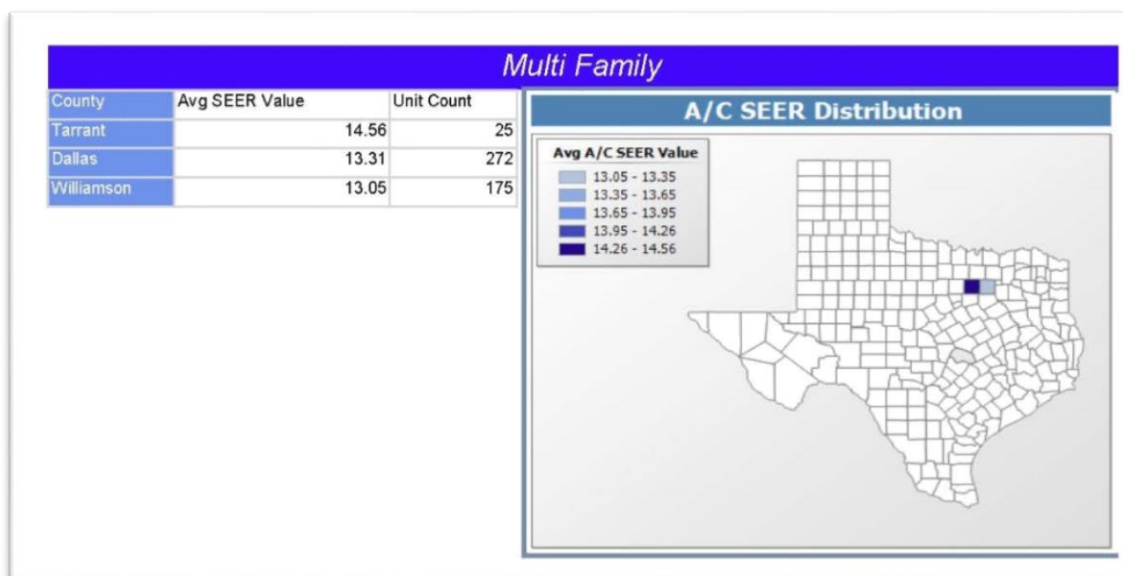
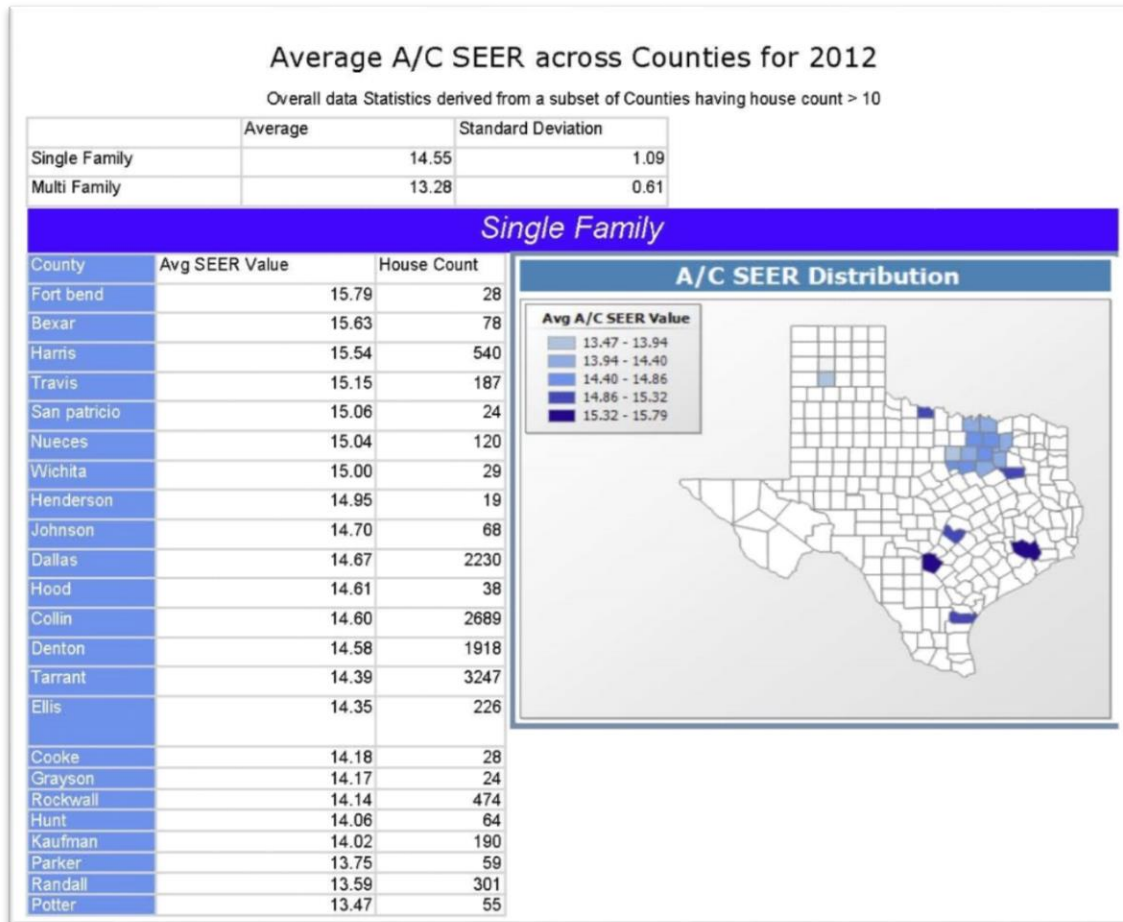


Figure 18: Average SEER 2012

The efficiency (and sizing) of air conditioning is a vital component of energy efficiency in Texas.

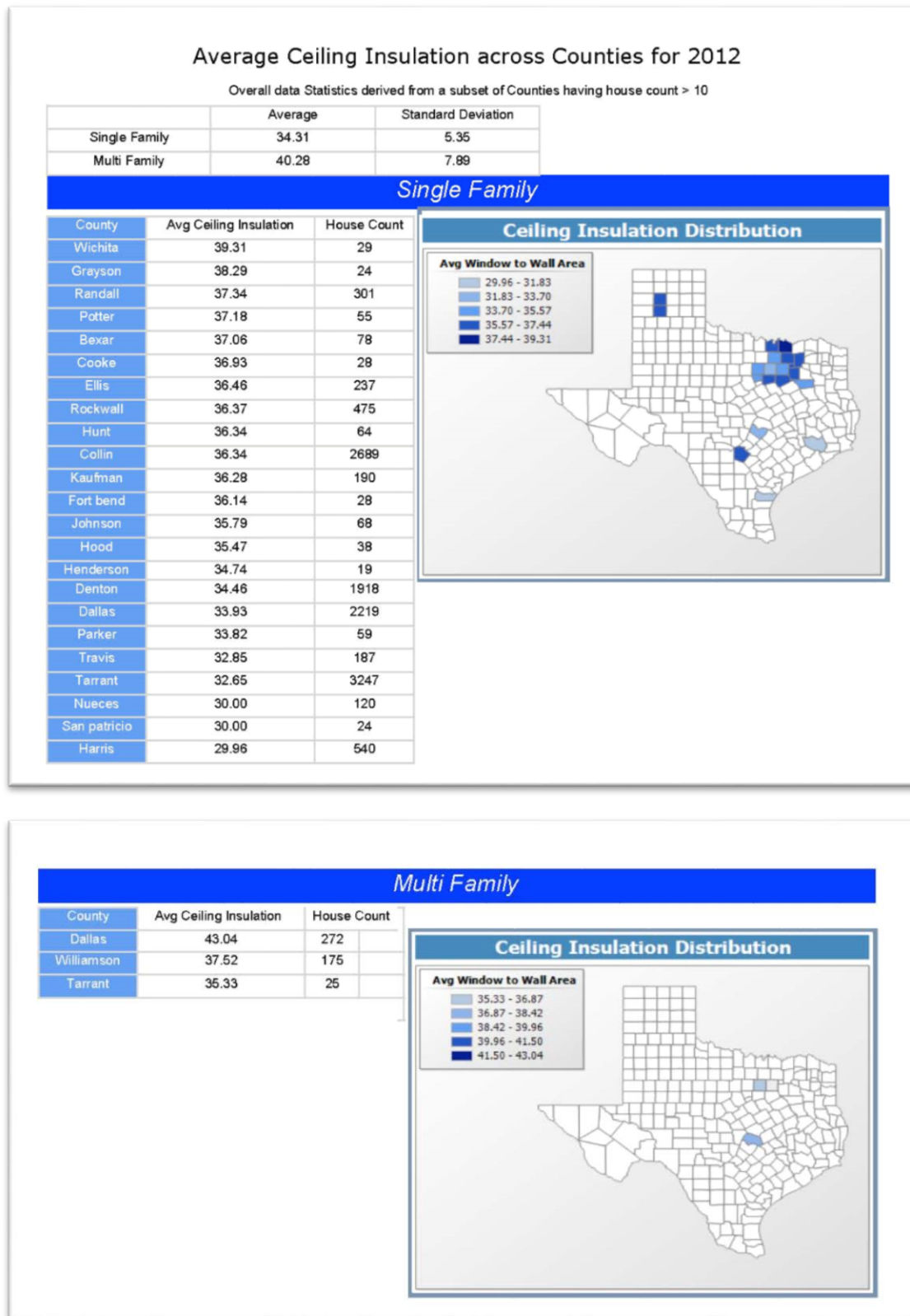
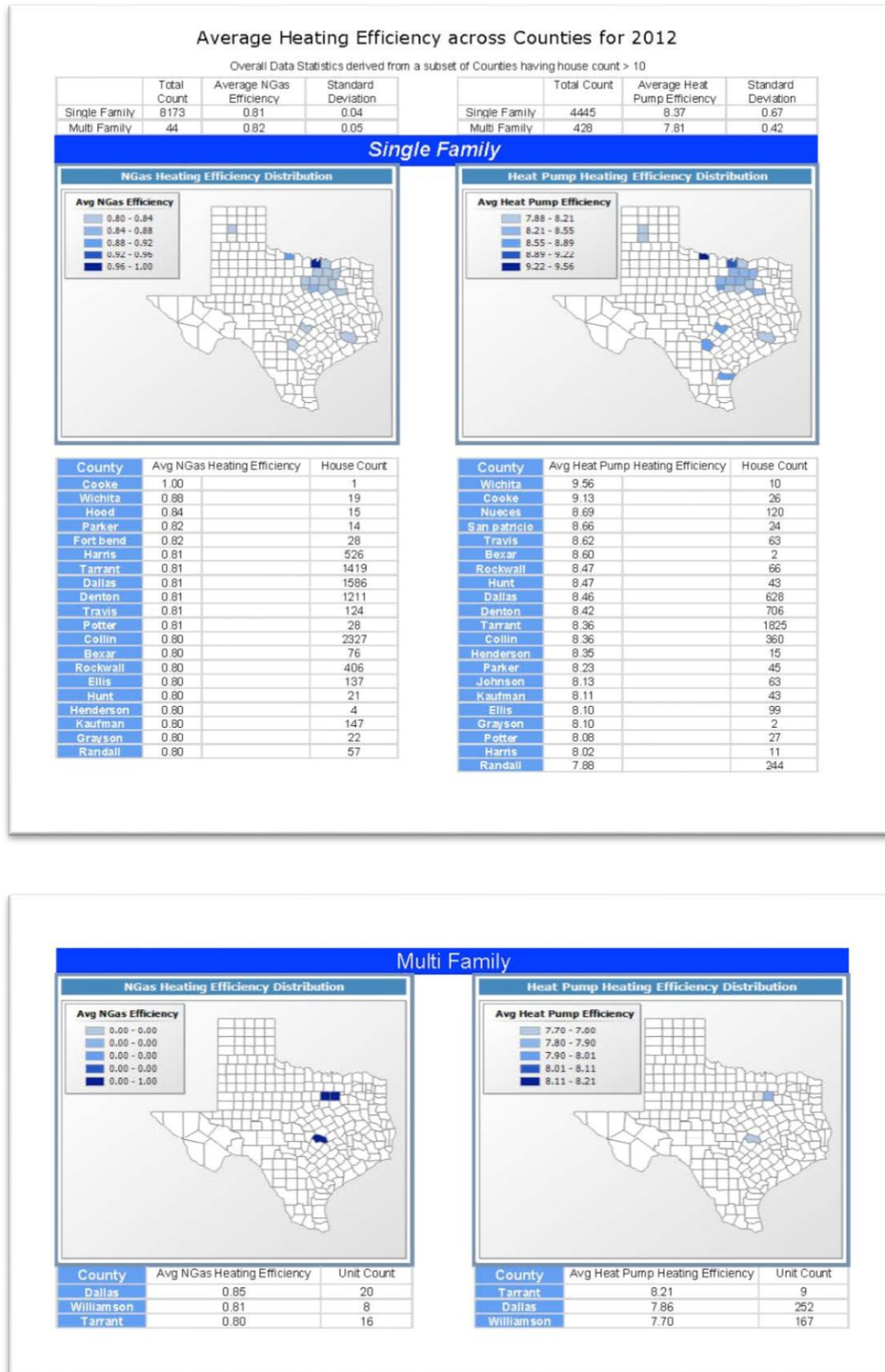


Figure 19: Average Ceiling Insulation 2012



##### NGas Heating Efficiency Distribution

**Avg NGas Efficiency**

- 0.00 - 0.00
- 0.00 - 0.00
- 0.00 - 0.00
- 0.00 - 0.00
- 0.00 - 1.00

##### Heat Pump Heating Efficiency Distribution

**Avg Heat Pump Efficiency**

- 7.70 - 7.80
- 7.80 - 7.90
- 7.90 - 8.01
- 8.01 - 8.11
- 8.11 - 8.21

County	Avg NGas Heating Efficiency	Unit Count
Dallas	0.85	20
Williamson	0.81	8
Tarrant	0.80	16

County	Avg Heat Pump Heating Efficiency	Unit Count
Tarrant	8.21	9
Dallas	7.86	252
Williamson	7.70	167

Figure 20: Average Heating Efficiency 2012

Here we examine space heating efficiency in 2012 using both natural gas and heap pump heating.

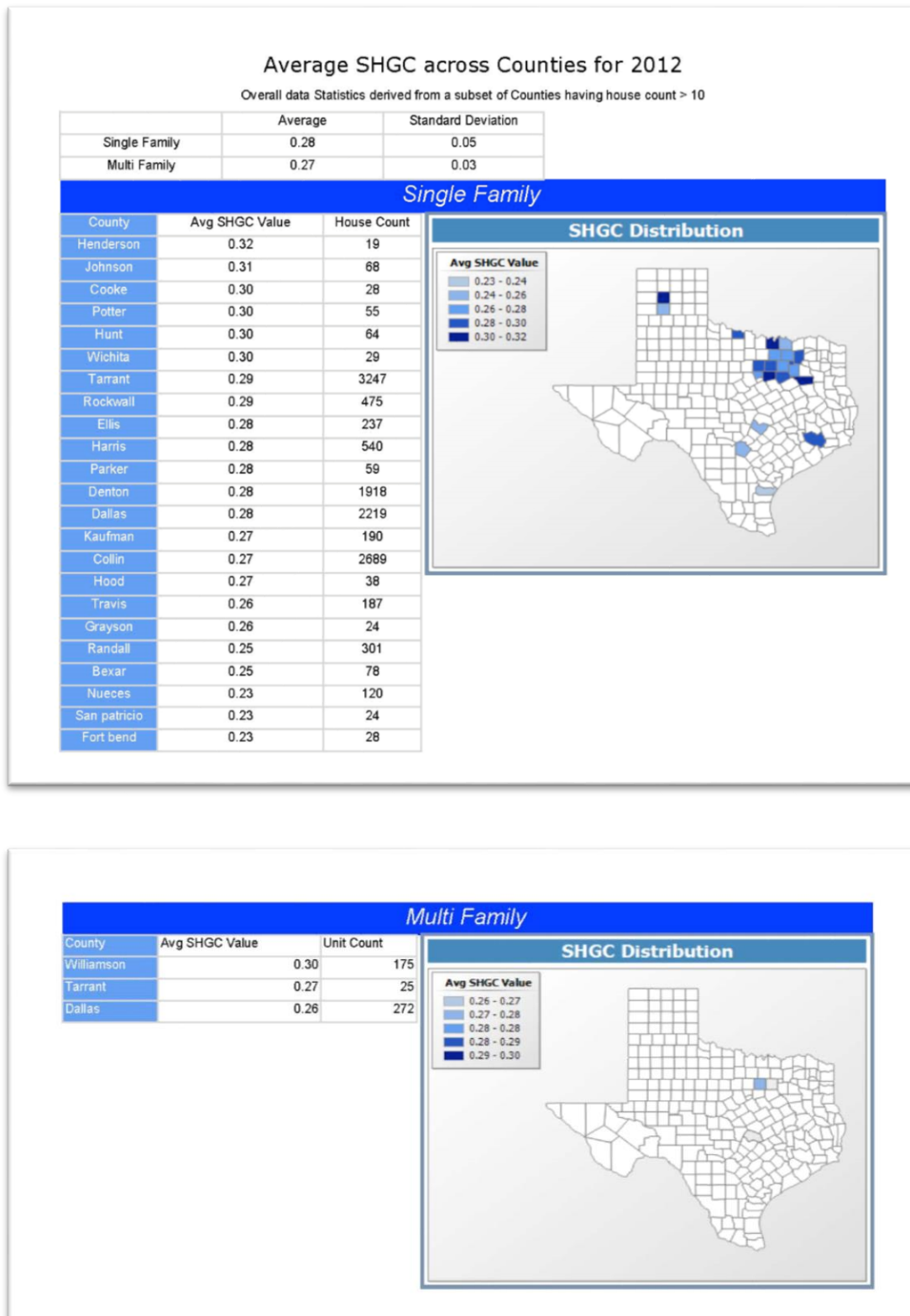


Figure 21: Average SHGC 2012



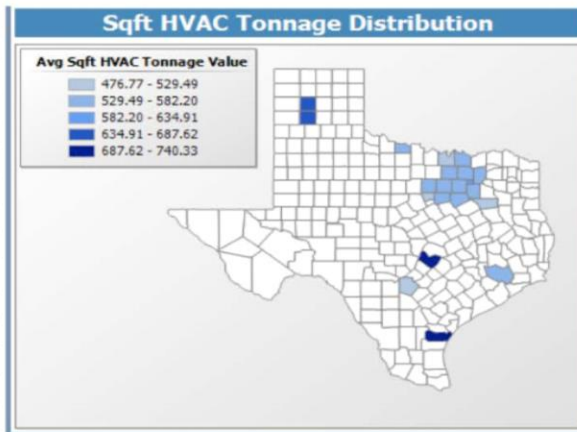
### Average HVAC across Counties for 2012

Overall data Statistics derived from a subset of Counties having house count > 10

	Average	Standard Deviation
Single Family	564.96	133.97
Multi Family	683.25	283.37

#### Single Family

County	Avg Sqft Tonnage Value	House Count
San Patricio	740.33	24
Travis	721.15	187
Nueces	719.03	120
Potter	679.54	55
Randall	646.25	301
Rockwall	587.40	475
Wichita	575.71	29
Harris	566.71	540
Tarrant	566.15	3247
Collin	562.84	2689
Denton	559.77	1918
Hunt	557.31	64
Grayson	556.06	24
Johnson	551.91	68
Kaufman	551.30	190
Ellis	547.22	237
Parker	541.45	59
Dallas	537.52	2219
Bexar	520.14	78
Henderson	511.56	19
Hood	487.85	38
Cooke	483.20	28
Fort bend	476.77	28



#### Multi Family

County	Avg Sqft Tonnage Value	Unit Count
Dallas	758.44	26
Tarrant	654.29	14
Williamson	564.06	13

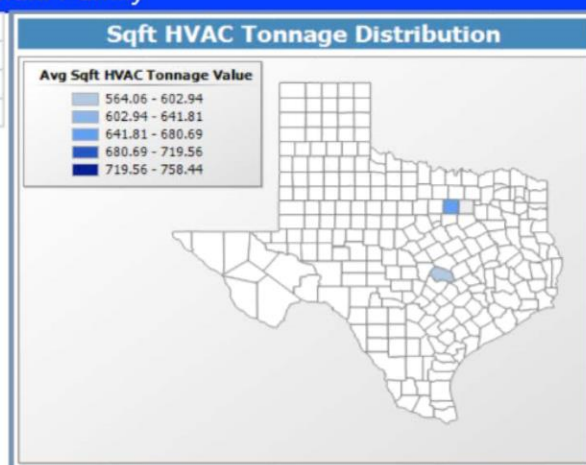


Figure 22: Average HVAC Tonnage to Sq Ft 2012

Another way to evaluate high performing houses is how much air conditioning they have per sq. ft. of house. Here we see ranges, for single family homes, of 475 to 741 sq. ft. per ton with an average of 565 sq. ft. per ton. Last year's average was 558 sq. ft. per ton. Thus, Texas is becoming more efficient.

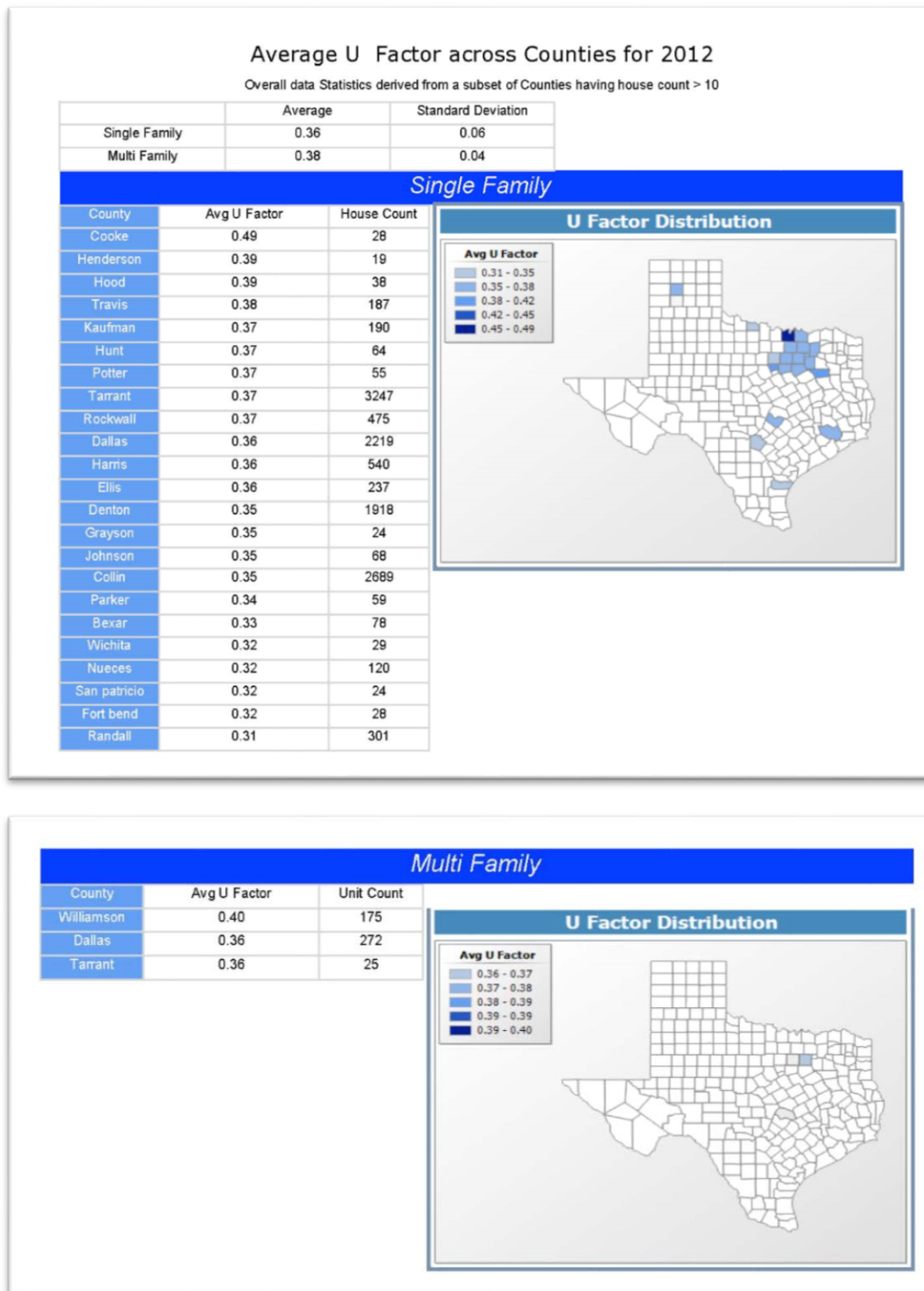


Figure 23: Average U Factor 2012

The U Factor applies to the heat transfer of a window caused by temperature, no direct solar radiation.



### 1.9 Code Adoption

One of the TERP's energy efficiency programs to reduce emissions from stationary sources was the establishment of the Texas Building Energy Performance Standards (TBEPS) that define the building energy codes for all new residential and commercial construction statewide. The original TBEPS were based on the energy efficiency chapter of the 2000 International Residential Code (IRC), including the 2001 Supplement, for single-family residences, (i.e., one- and two-family residences of three stories or less above grade) and the 2000 International Energy Conservation Code (IECC), including the 2001 Supplement, for commercial, industrial and residential buildings over three stories.

Over the years since the establishment of the TERP, newer editions of the IRC and the IECC have been published. The Energy Systems Laboratory was mandated to review the stringency of the new code editions and provide recommendations to the State on whether to upgrade the TBEPS to the new editions. In the time frame of 2002-2009, with the laboratory's recommendations and additional input from stakeholder meetings and public comment periods, the State of Texas did not adopt any of the newer editions of the energy efficiency codes as the TBEPS. During this timeframe, several individual jurisdictions did adopt the newer editions of the IRC and the IECC.

With the laboratory's recommendation, on April 1, 2011, SECO updated the TBEPS commercial and residential (excluding single-family) energy codes to the 2009 International Energy Conservation Code (IECC). On January 1, 2012, the TBEPS for single-family residential was updated to Chapter 11 (Energy Efficiency) of the 2009 International Residential Code (IRC).

In July 2011, the Laboratory began the stringency review of the newly published 2012 IRC and IECC. In December 2011, the Laboratory provided the findings of the technical analysis of stringency to SECO, indicating that both the residential and the commercial provisions of the 2012 code are more stringent than the TBEPS, which are based on the 2009 code. In 2012, in accordance with the Health and Safety Code Section 388.003, as amended, the Laboratory reviewed and considered all 1,526 comments collected by SECO from both the individuals and the large constituencies during the public comment period. In July, 2012, the Laboratory held a stakeholders meeting in which the Laboratory presented the stringency analysis and findings and reviewed the public comments consideration and analysis. In August 2012 the Laboratory provided SECO with a final recommendation and analysis regarding the stringency and environmental impact of Chapter 11, 2012 IRC and the 2012 IECC versus the current TBEPS, based on Chapter 11 of the 2009 IRC and the 2009 IECC. The Laboratory recommended SECO to adopt Chapter 11 of the 2012 IRC, as published, as the state-mandated energy code for all residential construction, one- and two-family residences of three stories or less above grade, and to adopt the 2012 IECC, as published, for commercial, industrial and residential buildings over three stories.

As of the time of this report, SECO has not adopted the 2012 code.

Table 4: Code adoptions

CITY NAME	General Building Code (IBC)	Residential Building Code (IRC)	Energy Code (IECC)	Electrical Code (NEC)	Mechanical Code (IMC)	Plumbing Code (UPC)	Green Building Code	Existing Building Code (EBEC)	Other Codes
Abilene	2003	2003	2006	2008	2003	2003	N/A	2003	2003 FGC
Addison									
Allen									
Amarillo	2006	2006	2006	2008	2006	2006	N/A	2006	2006 FC, 2006 IFGC
Angleton									
Arlington	2003	2003	2003	2002	2003	2003	N/A	N/A	2003 FC, 2003 IFGC
Austin									
Baytown	2006	2006	2006	2008	2006	2006	N/A	2006	N/A
Beaumont									
Bedford									
Big Spring	2006	2006	2006	2005	2006	2006	N/A	2006	N/A
Borger									
Brownsville	2006	2006	2006	2008	2006	2006	N/A	N/A	2006 FGC
Bryan	2003	2003	2003	2002	2003	2003	N/A	2003	2003 FGC
Burleson	2006	2006	2006	2005	2006	2006	N/A	N/A	North Central Texas Council of Government Amendment
Carrollton *	2006	2006	2006	2008	2006	2006	N/A	N/A	NCTCOG Recommended Regional Amendmentz
Cedar Hill	2006	2006	2006	2008	2006	2006	N/A	N/A	2006 FGC
Cedar Park	2009	2009	2009	2008	2009	2009	N/A	2008	2006 FC with Amendments, 2009 PMC
Cleburne	2003	2003	2003	2002	2003	2003	N/A	N/A	N/A
College Station	2009	2009	2009	2008	2009	2009	N/A	N/A	N/A
Conroe	2003	N/A	N/A	2008	2006	2006	N/A	N/A	2003 FC
Coppell	N/A	2006	2006	2005	2006	2006	N/A	2006	2006 FC, 2006 IFGC, 2006 PMC
Copperas Cove									
Corpus Christi	2003	2003	2003	2002	2003	2003	N/A	N/A	N/A
Corsicana	2009	2009	N/A	2008	2009	2009	N/A	N/A	N/A
Dallas	2006	2006	2006	2008	2006	2006	City of Dallas Ordinance #09070	2003	2006 IFC, 2006 IFGC
Deer Park									
Del Rio									
Denton									

CITY NAME	General Building Code (IBC)	Residential Building Code (IRC)	Energy Code (IECC)	Electrical Code (NEC)	Mechanical Code (IMC)	Plumbing Code (UPC)	Green Building Code	Existing Building Code (EBEC)	Other Codes
Desoto	2003	2003	2003	2002	2003	2003	N/A	N/A	N/A
Devine									
Duncanville	2008	2008	2008	2008	2008	2008	N/A	N/A	2008 FGC, 2008 PMC
Eagle Pass	2009	2009	2009	2008	2008	2009	N/A	2006	N/A
Edinburg									
El Paso									
Euless	2003	2003	2003	2002	2003	2003	N/A	N/A	2003 FC, 2003 IFGC, 2003 PMC
Farmers Branch									
Flower Mound									
Fort Worth	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 FGC
Friendwood	2009	2009	2009	2008	2009	2009	N/A	N/A	N/A
Frisco									
Galveston	2009	2009	2009	2008	2009	2009	N/A	N/A	2009 FC, 2009 PMC
Garland	2003	2003	2003	2006	2003	2003	N/A	N/A	N/A
Georgetown	2003	2009	2009	2002	2003	2003	N/A	2003	N/A
Grand Prairie	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 FC, 2003 IFGC
Grapevine	2006	2006	2006	2005	2006	2006	N/A	2006	N/A
Greenville	2006	2006	2006	2005	2006	2006	N/A	2006	N/A
Haltom City	2003	2003	2003	2002	2003	2003	N/A	N/A	N/A
Harker Heights	2009	2009	2009	2008	2009	2009	N/A	2006	2009 FC, 2009 IFGC
Harlingen									
Houston									
Huntsville	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 IFC, 2003 IFGC, 2003 PMC
Hurst	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 PMC
Irving	2006	2006	2006	2008	2006	2006	N/A	N/A	2006 FC, 2006 IFGC
Keller	2006	2006	2006	2006	2006	2006	N/A	N/A	2006 IFGC
Killeen									
Kingville									
Kyle	2009	2009	2009	1995	2009	2009	N/A	N/A	2009 PMC
La Porte									
Lake Jackson									
Lancaster	2003	2003	2003	2002	2003	2003	N/A	N/A	2003 PMC

Table 4: Code adoptions (continued)

CITY NAME	International Building Code (IBC)	International Residential Building Code (IRC)	Energy Code (IECC)	International Mechanical Code (IMC)	International Fire Code (IFC)	Plumbing Code (IPC)	Green Building Code	Existing Building Code (EBC)	Other Codes
Desoto	2003	2003	2003	2002	2003	2003	N/A	N/A	N/A
Devine									
Duncanville	2008	2008	2008	2008	2008	2008	N/A	N/A	2008 FGC, 2006 PMC
Eagle Pass	2009	2009	2009	2006	2006	2009	N/A	2006	N/A
Edinburg									
El Paso									
Euless	2003	2003	2003	2002	2003	2003	N/A	N/A	2003 FC, 2003 FGC, 2003 PMC
Farmers Branch									
Flower Mound									
Fort Worth	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 FGC
Friendwood	2009	2009	2009	2006	2009	2009	N/A	N/A	N/A
Frisco									
Galveston	2009	2009	2009	2006	2009	2009	N/A	N/A	2009 FC, 2009 PMC
Garland	2003	2003	2003	2006	2003	2003	N/A	N/A	N/A
Georgetown	2003	2003	2003	2002	2003	2003	N/A	2003	N/A
Grand Prairie	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 FC, 2003 FGC
Grapevine	2006	2006	2006	2006	2006	2006	N/A	2006	N/A
Greenville	2006	2006	2006	2006	2006	2006	N/A	2006	N/A
Haltom City	2003	2003	2003	2002	2003	2003	N/A	N/A	N/A
Harker Heights	2009	2009	2009	2006	2009	2009	N/A	2009	2009 FC, 2009 FGC
Hedberg									
Houston									
Huntsville	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 FC, 2003 FGC, 2003 PMC
Hurst	2003	2003	2003	2006	2003	2003	N/A	N/A	2003 PMC
Irving	2006	2006	2006	2006	2006	2006	N/A	N/A	2006 FC, 2006 FGC
Keller	2006	2006	2006	2006	2006	2006	N/A	N/A	2006 FGC
Killeen									
Kingsville									
Kyle	2009	2009	2009	2006	2009	2009	N/A	N/A	2009 PMC
La Porte									
Lake Jackson									
Lancaster	2003	2003	2003	2002	2003	2003	N/A	N/A	2003 PMC

CITY NAME	International Building Code (IBC)	International Residential Building Code (IRC)	Energy Code (IECC)	International Mechanical Code (IMC)	International Fire Code (IFC)	Plumbing Code (IPC)	Green Building Code	Existing Building Code (EBC)	Other Codes
San Antonio									
San Benito	2009	2009	2009	N/A	2009	2009	N/A	N/A	2009 FGC, 2009 PMC, 2009 IMC
San Juan	2006	2006	2006	2006	2006	2006	N/A	2006	2006 FGC/American Residential Construction
San Marcos									
Schertz									
Seguin	2006	2006	2006	2006	2006	2006	N/A	2006	N/A
Sherman	2006	2006	2006	2006	2006	2006	N/A	N/A	N/A
Secor	2003	2003	2003	2003	2003	2003	2003	2003	N/A
Southlake	2006	2006	2006	2006	2006	2006	N/A	N/A	N/A
Sugar Land	2003	2003	2003	2006	2003	2003	N/A	2003	2003 FC, 2003 FGC, 2003 PMC
Temple	2006	2006	2006	2006	2006	2006	N/A	N/A	2006 FGC, 2006 PMC
Tesarkana									
Texas City	2006	2006	2006	2006	2006	2006	2006	2006	N/A
The Colony	2006	2006	2006	2006	2006	2006	N/A	N/A	N/A
Tyler									
Victoria									
Vaco	2009	2009	2009	2006	2009	2009	N/A	2009	2009 FC, 2009 FGC, 2009 PMC
Vashachie									
Weatherford									
Vestaco									
Victoria Falls	2006	2006	2006	2006	2006	2006	N/A	2006	N/A

Section 388.009 of HB 3235 requires the Laboratory to develop and administer a state-wide training program for municipal building inspectors who seek to become code-certified inspectors. To accomplish this, the Laboratory originally developed the Energy Code Workshops which were based on the 2006 International Energy Conservation Code (IECC) as published by the International Code Council (ICC) for residential and commercial buildings, with amendments. Since then, the Laboratory has updated the workshops to the 2009 IECC, and developed preliminary versions of 2012 code workshops. During 2012, the Laboratory provided and was involved in various energy-code-related trainings. These included:

- 2009 IECC Commercial Provisions Training;

- 2009 IECC Residential Provisions Training;
- 2009 IECC Fundamentals for Commercial Provisions Training; and
- 2009 IECC Fundamentals for Residential Provisions Training.
- Common Sense Construction Using the Energy Code
- 2012 IECC
- ASHRAE Standard 90.1-2010
- ASHRAE Standard 90.1-2010. Online Training Part I: Overview
- ASHRAE Standard 90.1-2010. Online Training Part II: Envelope Provisions
- ASHRAE Standard 90.1-2010. Online Training Part III: HVAC Provisions
- ASHRAE Standard 90.1-2010. Online Training Part IV: Mechanical Provisions
- ASHRAE Standard 90.1-2010. Online Training Part V: Lighting Provisions

Additional workshops included

- New Funding Alternatives, Sources and Strategies to Create High-Performing, Energy Efficient Buildings
- Which Green Rating System is Right for You?
- Energy Management for Schools
- Insulation Strategies & Coated Foam Roofing Systems
- Energy Efficiency Changes & Local Above Code Programs
- Pathway to Net Zero Homes & Innovations in PV
- High Performance Homes & Selling High Performance Homes
- Diagnostic Tools & Lighting Technologies
- Commercial Buildings - Evaluation Opportunities & HVAC Economizers
- A Methodology for Calculating Integrated NOx Emissions Reductions From Energy Efficiency And Renewable Energy (EE/RE) Programs Across State Agencies In Texas. Online Webinar.

In July 2011, the Laboratory was awarded a grant from the State Energy Conservation Office to conduct ASHRAE Standard 90.1-2010 Workshops across the State of Texas (ARRA funded). The project continued through March 31, 2012. The primary goal of this project was to help train and fully familiarize the State agency staff, code enforcement personnel, engineers and architects with the content of this newly adopted standard in order to effectively implement the provisions of the ASHRAE 90.1-2010 in Texas. Participants of this workshop examined the latest ASHRAE energy efficiency standards for commercial buildings, were able to identify and compare the substantive changes/additions made since the 2007 ASHRAE edition, were equipped to evaluate the mandatory and prescriptive HVAC, envelope, service water heating, and lighting criteria and to identify applicable IRS energy tax credits and Code Compliance Software when applying the Standards. Overall, a total of nine (9) full-day workshop sessions were conducted, to a total of 340 participants. With the success of the program, the workshop was re-edited for videotaping purposes, and the video filming and production were completed successfully. The online sessions are available on SECO's website at: <http://seco.cpa.state.tx.us/tbec/videos.php>.

The Laboratory collaborated with the South-central Partnership for Energy Efficiency as a Resource (SPEER) to provide other educational workshops on strategies to advance high performance homes and buildings. The project, funded by SECO, began in May 2012 and continued into 2013. By December 2012, three (3) different types of workshops were developed and ten (10) total six-hour workshops have been delivered by the SPEER to a total of 534 participants.

In addition, the Laboratory provided 2009 code trainings at the two BPI annual conferences, and a 2012 code training in El Paso.

The total number of workshops held by the Energy Systems Laboratory for the year 2012 was 31 with 957 participants, and over 510 additional participants in the online training sessions.

Table 4: List of all short courses/workshops conducted in 2012

<b>Short Courses/Workshops</b>				
<b>Course Title</b>	<b>Description</b>	<b>Date</b>	<b>Location</b>	<b>Attendance</b>
2009 IECC – Commercial Provisions	Full Day training	2/1/2012	Houston, TX (12 <sup>th</sup> Annual Building Professional Institute)	25
2009 IECC – Residential Provisions	Full Day training	2/1/2012	Houston, TX (12 <sup>th</sup> Annual Building Professional Institute)	18
ASHRAE Standard 90.0-2010	Full day training	2/3/2012	Corpus Christi, TX	50
ASHRAE Standard 90.0-2010	Full day training	2/15/2012	Houston, TX	25
2009 IECC Commercial Provisions	Full day training	5/21/2012	Arlington, TX (20 <sup>th</sup> Annual Building professional Institute)	25
2009 IECC Residential Provisions	Full day training	5/22/2012	Arlington, TX (20 <sup>th</sup> Annual Building professional Institute)	40
Common Sense Construction Using the Energy Code	Full day training	5/23/2012	Arlington, TX (20 <sup>th</sup> Annual Building professional Institute)	32
Insulation Strategies & Coated Foam Roofing Systems	3 Hour Workshop	9/17/2012	Austin, TX	21
Energy Efficiency Changes & Local Above Code Programs	3 Hour Workshop	9/17/2012	Austin, TX	34
Insulation Strategies & Coated Foam Roofing Systems	3 Hour Workshop	9/18/2012	DFW, TX	20
Energy Efficiency Changes & Local Above Code Programs	3 Hour Workshop	9/18/2012	DFW, TX	30
Insulation Strategies & Coated Foam Roofing Systems	3 Hour Workshop	9/20/2012	San Antonio, TX	22
Energy Efficiency Changes & Local Above Code Programs	3 Hour Workshop	9/20/2012	San Antonio, TX	29
Insulation Strategies & Coated Foam Roofing Systems	3 Hour Workshop	9/21/2012	Houston, TX	37
Energy Efficiency Changes & Local Above Code Programs	3 Hour Workshop	9/21/2012	Houston, TX	36
2012 IECC	6 Hour Workshop	9/21/2012	El Paso, TX	49

New Funding Alternatives, Sources and Strategies to Create High-Performing, Energy Efficient Buildings	2 Hour Workshop	10/9/2012	Galveston, TX	<b>65</b>
Which Green Rating System is Right for You?	4 Hour Workshop	10/9/2012	Galveston, TX	<b>55</b>
Energy Management for Schools	4 Hour Workshop	10/9/2012	Galveston, TX	<b>39</b>
Pathway to Net Zero Homes & Innovations in PV	3 Hour Workshop	10/23/2012	Austin, TX	26
High Performance Homes & Selling High Performance Homes	3 Hour Workshop	10/23/2012	Austin, TX	24
Pathway to Net Zero Homes & Innovations in PV	3 Hour Workshop	10/24/2012	San Antonio, TX	11
High Performance Homes & Selling High Performance Homes	3 Hour Workshop	10/24/2012	San Antonio, TX	9
Diagnostic Tools & Lighting Technologies	3 Hour Workshop	12/5/2012	San Antonio, TX	19
Commercial Bldg - Evaluation Opportunities & HVAC Economizers	3 Hour Workshop	12/5/2012	San Antonio, TX	18
Diagnostic Tools & Lighting Technologies	3 Hour Workshop	12/6/2012	Houston, TX	33
Commercial Bldg - Evaluation Opportunities & HVAC Economizers	3 Hour Workshop	12/6/2012	Houston, TX	33
Diagnostic Tools & Lighting Technologies	3 Hour Workshop	12/7/2012	Austin, TX	26
Commercial Bldg - Evaluation Opportunities & HVAC Economizers	3 Hour Workshop	12/7/2012	Austin, TX	24
Diagnostic Tools & Lighting Technologies	3 Hour Workshop	12/11/2012	Dallas, TX	46
Commercial Bldg - Evaluation Opportunities & HVAC Economizers	3 Hour Workshop	12/11/2012	Dallas, TX	36
<b>Total of 31 workshops</b>				<b>957</b>
ASHRAE Standard 90.0-2010. Part I: Overview	34 minutes online training video	Available since April 2012	Online, uploaded by the Texas State Energy Conservation Office (SECO)	183
ASHRAE Standard 90.0-2010. Part II: Envelope Provisions	42 minutes online training video	Available since April 2012	Online, uploaded by SECO	113
ASHRAE Standard 90.0-2010. Part III: HVAC Provisions	19 minutes online training video	Available since April 2012	Online, uploaded by SECO	80
ASHRAE Standard 90.0-2010. Part IV: Mechanical Provisions	31 minutes online training video	Available since April 2012	Online, uploaded by SECO	45
ASHRAE Standard 90.0-2010. Part V: Lighting Provisions	28 minutes online training video	Available since April 2012	Online, uploaded by SECO	89

A Methodology for Calculating Integrated NOx Emissions Reductions From Energy Efficiency And Renewable Energy (EE/RE) Programs Across State Agencies In Texas	1.5 hours webinar	8/8/2012	Online, sponsored by The State Energy Efficiency Action Network (SEE Action), U.S. EPA State Climate & Energy Program	unknown
<b>Total of 6 online training sessions</b>				<b>510+</b>
<b>Total Trainees</b>				<b>1,467+</b>

Slides from the ASHRAE 90.1 Standard Update Workshops which were presented all in six different locations in the State of Texas in 2012





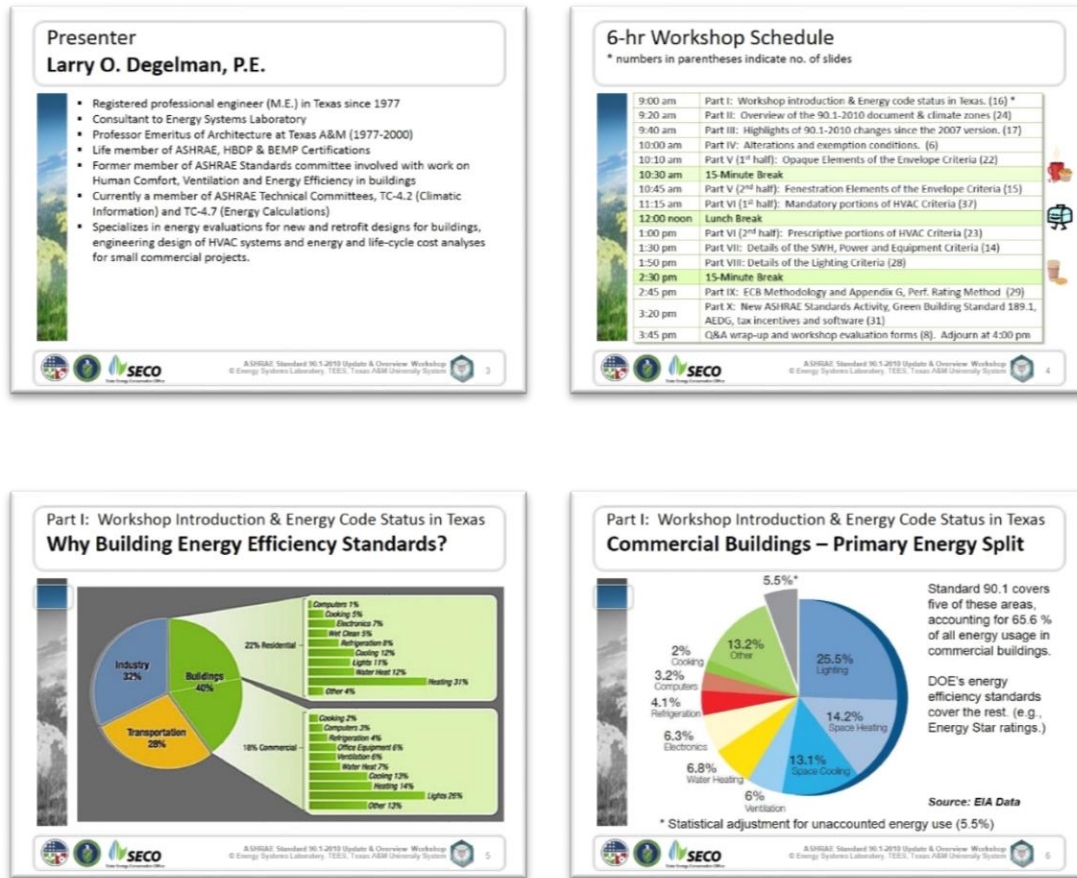
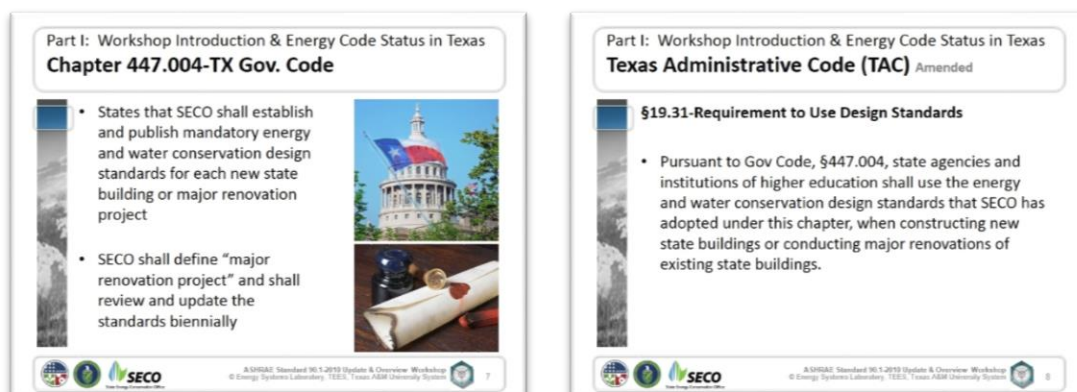


Figure 24: ASHRAE 90.1 Standard Update Workshop





Part I: Workshop Introduction & Energy Code Status in Texas  
**Texas Administrative Code (TAC) Amended**

**§19.32-Energy & Water Design Standards**

- (1) for any new construction or major renovation project, except low-rise residential buildings, with a design assignment made on or after September 1, 2011, ASHRAE 90.1-2010.
- (2) for any new construction or major renovation project for a public low-rise residential buildings with a design assignment made on or after June 1, 2011, IECC-2009.

Part I: Workshop Introduction & Energy Code Status in Texas  
**Texas Administrative Code (TAC) Amended**

**§19.32-Energy & Water Design Standards**

- (3) Effective September 1, 2011, SECO adopts by reference the "Water Efficiency Standards for State Buildings and Institutions of Higher Education Facilities prepared by SECO-CPA and dated January 2011 as the water conservation design standards for new state buildings and major renovation projects.  
(a) SECO Water Standards published at: [www.txbuildingenergycode.com](http://www.txbuildingenergycode.com)

Part I: Workshop Introduction & Energy Code Status in Texas  
**Texas Administrative Code (TAC) Amended**

**§19.33-Major Renovation Projects**

- For the purpose of 34 TAC, Chapter 19, Subchapter C, a major renovation project is a building renovation or improvement where the implementation cost is \$2,000,000.00 or more, based on the initial cost estimate.

Part I: Workshop Introduction & Energy Code Status in Texas  
**Texas Administrative Code (TAC) Amended**

**§19.34-Submission of Certification and Compliance Documentation**

- Before beginning construction of a new state building or a major renovation project, including a new building or major renovation project of a state-supported institution of higher education, a state agency or an institution of higher education shall submit to SECO a copy of the certification by the design architect or engineer that verifies to the agency or institution of that the construction or renovation complies with the standards that are established under this chapter, including engineering documentation.

Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

Part I: Workshop Introduction & Energy Code Status in Texas  
**TX State Code Compliance Form Sample segment/Top**

ENERGY CONSERVATION DESIGN STANDARD COMPLIANCE CERTIFICATION FOR NONRESIDENTIAL BUILDINGS

Name of Building/Facility \_\_\_\_\_

Location of Building/Facility (Street Address) \_\_\_\_\_ City/State \_\_\_\_\_ Zip Code \_\_\_\_\_ County \_\_\_\_\_

Building Owner (Agency/Institution) \_\_\_\_\_ Agency/Institution Number \_\_\_\_\_

Mailing Address \_\_\_\_\_ City/State \_\_\_\_\_ Zip Code \_\_\_\_\_ County \_\_\_\_\_

Contact Person at Agency/Institution and Title \_\_\_\_\_ Telephone Number \_\_\_\_\_

Architect/Engineering Firm \_\_\_\_\_ Telephone Number \_\_\_\_\_

Mailing Address \_\_\_\_\_ City/State \_\_\_\_\_ Zip Code \_\_\_\_\_ County \_\_\_\_\_

Contact Person at Architect/Engineering Firm \_\_\_\_\_ Telephone Number \_\_\_\_\_

PROJECT DESCRIPTION ☐ New ☐ Renovation ☐ Addition

Total Sq. Ft. of Conditioned Space \_\_\_\_\_

Part I: Workshop Introduction & Energy Code Status in Texas  
**TX State Code Compliance Form Sample segment/Bottom**

Please provide brief description of project: \_\_\_\_\_

INDICATE METHOD USED TO VERIFY COMPLIANCE AND ATTACH DOCUMENTATION:

MANDATORY REQUIREMENTS PLUS ☐ PRESCRIPTIVE ☐ TRADE-OFF (ENVELOPE) ☐ ENERGY COST BUDGET

☐ COMPLIANCE WITH THE ECONOMIC FEASIBILITY OF INCORPORATING ALTERNATIVE ENERGY AND ENERGY EFFICIENT ARCHITECTURAL AND ENGINEERING DESIGN

☐ COMPLIANCE WITH THE STATE WATER EFFICIENCY STANDARDS

Having examined the Texas Design Standard for nonresidential buildings, based on ANSI-ASHRAE/IESNA Standard 90.1-2010, and being knowledgeable of provisions thereof, I do hereby certify the agency or institution listed above and the State Comptroller's Office, State Energy Conservation Office, of the above described project and conform, to the best of my professional ability, that the construction plans and specifications are in compliance with the provisions of the Standard in accordance with the Texas Government Code, Title 4, Ch. 447.004(a)(5).

Signature of Certifying Architect/Engineer \_\_\_\_\_

Date \_\_\_\_\_

(Affix Official TRA/TERP Seal)

TRA/TERP Registration No. \_\_\_\_\_

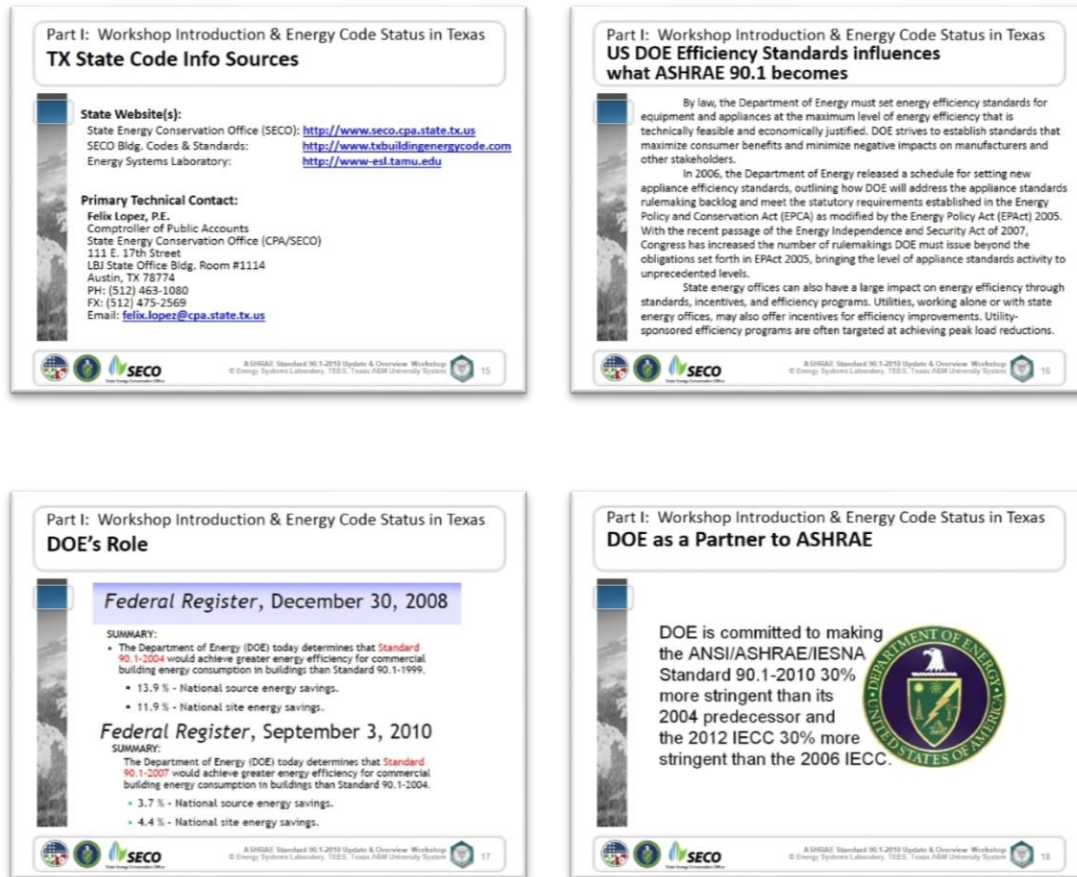
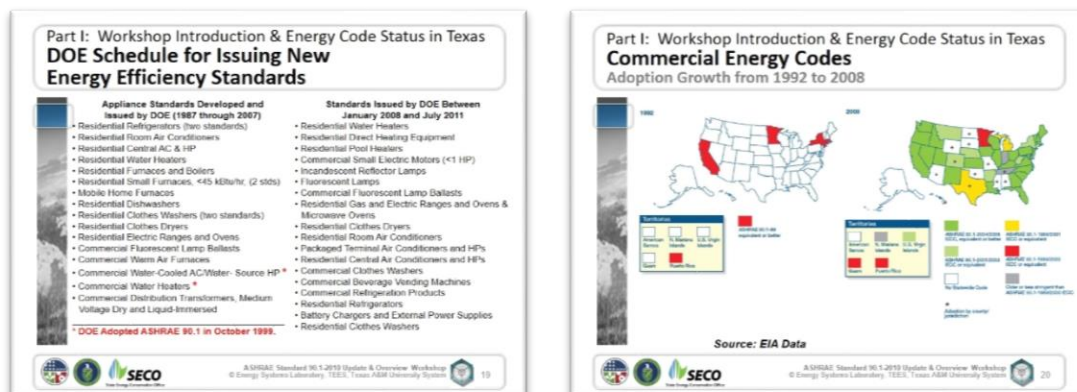


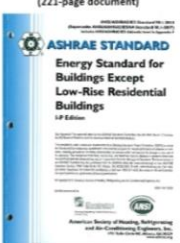
Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



Part II. Overview of 90.1-2010  
**Document Overview**

- It supercedes ANSI/ASHRAE/IESNA Standard 90.1-2007 by adding 60 Addenda.
- It will become the reference standard for the 2012 IECC.
- It is the professional "standard of care" for energy efficiency set by ASHRAE consensus.
- Format: Structured like a code document, with a consistent numbering scheme.
- Estimated savings compared to the 90.1-2007 version are about 25%, and about 30% compared to the 90.1-2004 version.
- Climate zones:
  - Defined geographically by county lines, not by individual city or climatic Degree Days.
  - Metropolitan areas kept together.

(221-page document)




ASHRAE STANDARD  
Energy Standard for Buildings Except Low-Rise Residential Buildings  
1st Edition

ASHRAE Standard 90.1-2010 Update & Overview Workshop  
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Part II. Overview of 90.1-2010  
**Energy Economics**

Criteria not on lowest energy use, but rather, on energy costs.  
Optimizations are Based on Life Cycle Cost (LCC)



Life Cycle Cost (LCC) Optimization

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Part II. Overview of 90.1-2010  
**Energy Economics**

**Economics Used in 2010 Standard**

- Fuel prices (Approved 30-0-1 by SSPC vote 1 April 2007)
  - \$1.22 / therm for heating fuel costs
  - \$0.0939 / kWh for electricity
- Scalar assumptions (Approved 24-1-7 by SSPC vote 1 April 2007)
  - Nominal escalation 3.7%
  - Same as the escalation rate for fuels. So the "real" inflation rate of fuels is 0%
  - State tax rate 5%
  - Nominal discount 7%
  - Nominal interest 7%
- 189.1 is not required to cost justify

ASHRAE Standard 90.1-2010 Update & Overview Workshop  
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Part II. Overview of 90.1-2010  
**The Document Structure**

**Sections in the document**

- Purpose
- Scope
- Definitions, Abbrev. & Acronyms
- Administration and enforcement
- Building envelope
- HVAC
- SWH
- Power
- Lighting
- Other equipment
- Energy Cost Budget (ECB)
- Normative References
- Appendices A – G

**Technical Sections Outline**

- General – Scope & conditions
- Compliance Paths
- Simplified Building
- Mandatory Provisions
- Prescriptive Compliance Path
- Alternative Compliance Path
- Submittals – Drawings, manuals, labeling, etc.
- Product Information – Equipment efficiencies, installation requirements, etc.

"Exceptions" are common and are stated under each requirement in the standard.

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Part II. Overview of 90.1-2010  
**Organization of Technical Sections**

**X.1 General – Scope, other special conditions**

**X.2 Compliance Paths**

**X.3 Simplified Building (only used in HVAC)**

**X.4 Mandatory Provisions**

- Must be followed for all buildings.

**X.5 Prescriptive Compliance Path**

- Must be followed or traded-off w/ ECB

**X.6 Alternative Compliance Path (only in section 5, Envelope, and section 9, Lighting)**

**X.7 Submittals – Drawings, manuals, labeling, etc.**

**X.8 Product Information – Equipment efficiencies, installation requirements, etc.**

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Part II. Overview of 90.1-2010  
**Section 1 – Purpose**

The purpose of this standard is to provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings for:

- design, construction, and plan for O&M, and \*\*
- Utilization of on-site, renewable energy sources.

"Low-rise residential" is defined as single-family homes, manufactured housing, and other residential structures that are less than 4 stories above grade.

**\*\* Note: The portion in red is new in the 2010 version.**

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Part II. Overview of 90.1-2010  
**Section 2 – Scope**

- Provisions apply to:
  - New building portions and systems in new and existing (renovated) buildings.
  - New equipment or systems that are identified as part of industrial or manufacturing processes.
- Envelope:
  - if heated by a heating system with an output capacity  $\geq 3.4 \text{ Btu/h-ft}^2$  or
  - if cooled by a cooling system with a sensible output capacity  $\geq 5 \text{ Btu/h-ft}^2$
- Virtually all mechanical, power, and lighting systems are covered

**\*\* Note: Red text portion new in the 2010 version.**

Part II. Overview of 90.1-2010  
**Section 3 – Definitions**

- Conditioned space:
  - cooled by a cooling system with a sensible output capacity  $> 5 \text{ Btu/h-ft}^2$
  - heated by a heating system with an output capacity  $\geq$  Table 3.1
  - indirectly conditioned space – adjacent to conditioned space but neither heated nor cooled
- Semiheated space: heated at  $\geq 3.4 \text{ Btu/h-ft}^2$ , but not classified as conditioned.
- Unconditioned space: e.g., crawl spaces, attics, etc.

Heating Output (Btu/h-ft <sup>2</sup> )	Climate Zone
5	1 and 2
10	3
15	4 and 5
20	6 and 7
25	8

Part II. Overview of 90.1-2010  
**Section 3 – Space Definitions**

Figure S-5 Space Definitions

Part II. Overview of 90.1-2010  
**Section 3 – Definitions 3.3 Abbreviations, Acronyms**

Some useful terms:

- EER = Energy Efficiency Ratio (Btu out/watt-hr. in, at approx. 95°F)
- kW/ton=12/EER
- SEER=Seasonal Energy Efficiency Ratio (Btu out/watt-hr. over all season.)
- IEER= Integrated Energy Efficiency Ratio (similar to SEER)
- COP= Coefficient of Performance (Btu out/Btu in, similar to "efficiency")
- EERs 3.4 \* COP
- HSPF=Heating Seasonal Performance Factor (Btu out/watt-hr)
- IPV=Integrated part load value = could be COP or EER at partial load.
- LPD=Lighting Power Density (W/ft<sup>2</sup>)
- EUI=Energy Utilization Index (Btu/ft<sup>2</sup>/yr)

Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

Part II. Overview of 90.1-2010  
**EUI Expressed Two Ways**

Part II. Overview of 90.1-2010  
**Section 4 – Administration & Enforcement**

Standard 90.1 applies to:

- New buildings
- Additions to existing buildings \*
- Alterations to existing buildings \*
- Replacement of parts of existing buildings \*
- Changes in HVAC \*

**\* Additions & alterations permit tradeoffs and have other exceptions.**



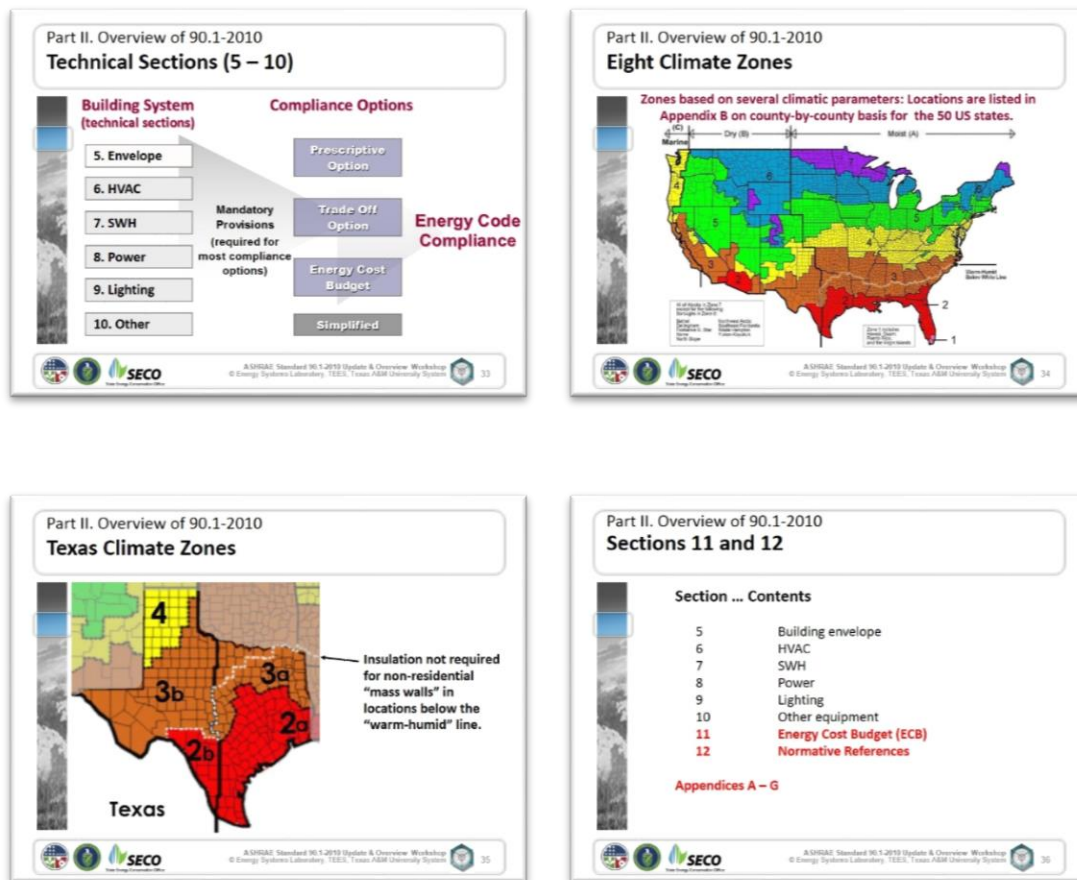
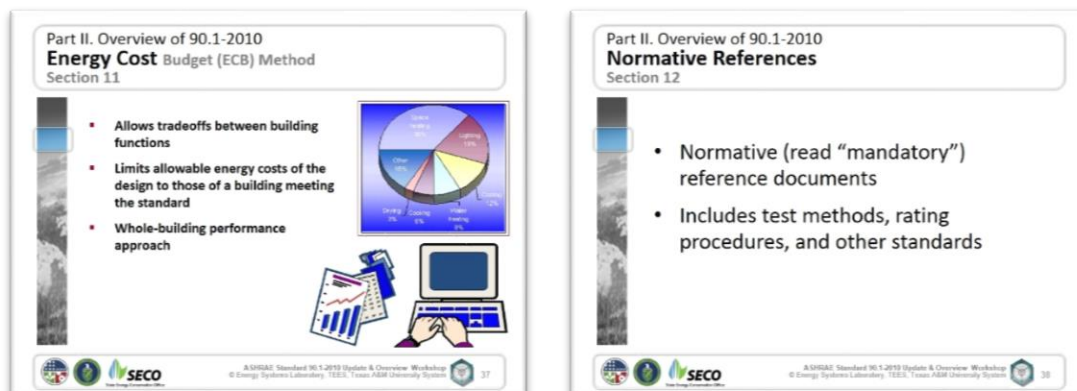


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



Part II. Overview of 90.1-2010  
**Appendices**

<p><b>NORMATIVE</b></p> <ul style="list-style-type: none"> <li>A. Assembly U-, C-, and F-Factor Determination</li> <li>B. Climate Zones Designations</li> <li>C. <u>Envelope Trade-Off Methodology</u></li> <li>D. Climatic Data</li> </ul> <p>Appendix G. Performance Rating Method (new)</p>	<p><b>INFORMATIVE</b></p> <ul style="list-style-type: none"> <li>E. Informative References</li> <li>F. Addenda Description Information</li> </ul>
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Part II. Overview of 90.1-2010  
**Assembly U.F., C-Factor & F-Factor Determination**  
Normative App. A

- Includes pre-calculated U-factors, C-factors, and F-factors
  - Above-grade walls
  - Below-grade walls
  - Floors
  - Slab-on-grade floors
  - Opaque doors
  - Fenestration

Part II. Overview of 90.1-2010  
**Building Envelope Climate Criteria**  
Normative Appendix B

- Tables B-1, B-2, and B-3 contain eight (8) climate zones designations for U.S. counties, Canadian Provinces & cities and other foreign cities.
- Table B-4 lists the climate zone criteria in terms of HDD65 and CDD50 ranges.

Part II. Overview of 90.1-2010  
**Envelope Trade-off Option**  
Normative Appendix C

- Appendix C contains the very detailed procedures (including equations) for calculating the building envelope trade-off.
- Up through the 2007 version, a computer program (EnvStd) was included in the 90.1 user's manual, which calculated the "Envelope Performance Factor" that allowed trade-offs among roof and wall elements. This was discontinued with the Version 6.0 issued in 2007. The "metric" of trade-off is an energy dollar trade-off that can be demonstrated by the same method as the ECB methodology.

Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

Part II. Overview of 90.1-2010  
**Climatic Data**  
Normative Appendix D

- 34 pages of climatic data for approx. 900 US, Canadian, and international cities.
- HDD<sub>65</sub> and CDD<sub>50</sub>
- Heating & cooling DB & WB design temperatures and the "number of hours between 8 am and 4 pm with T<sub>db</sub> between 55° and 69°" for HVAC calculations

Part II. Overview of 90.1-2010  
**Performance Rating Method**  
Appendix G

- The performance rating method is a modification of the ECB method in Section 11 and is intended for use in rating the energy *efficiency* of building designs that exceed the requirements of the standard. It is not an alternative path for compliance; rather, it is for those wishing to quantify performance that substantially exceeds the requirements of Standard 90.1, typically to gain LEED rating points.
- Like ECB, it requires the use of approved simulation software.

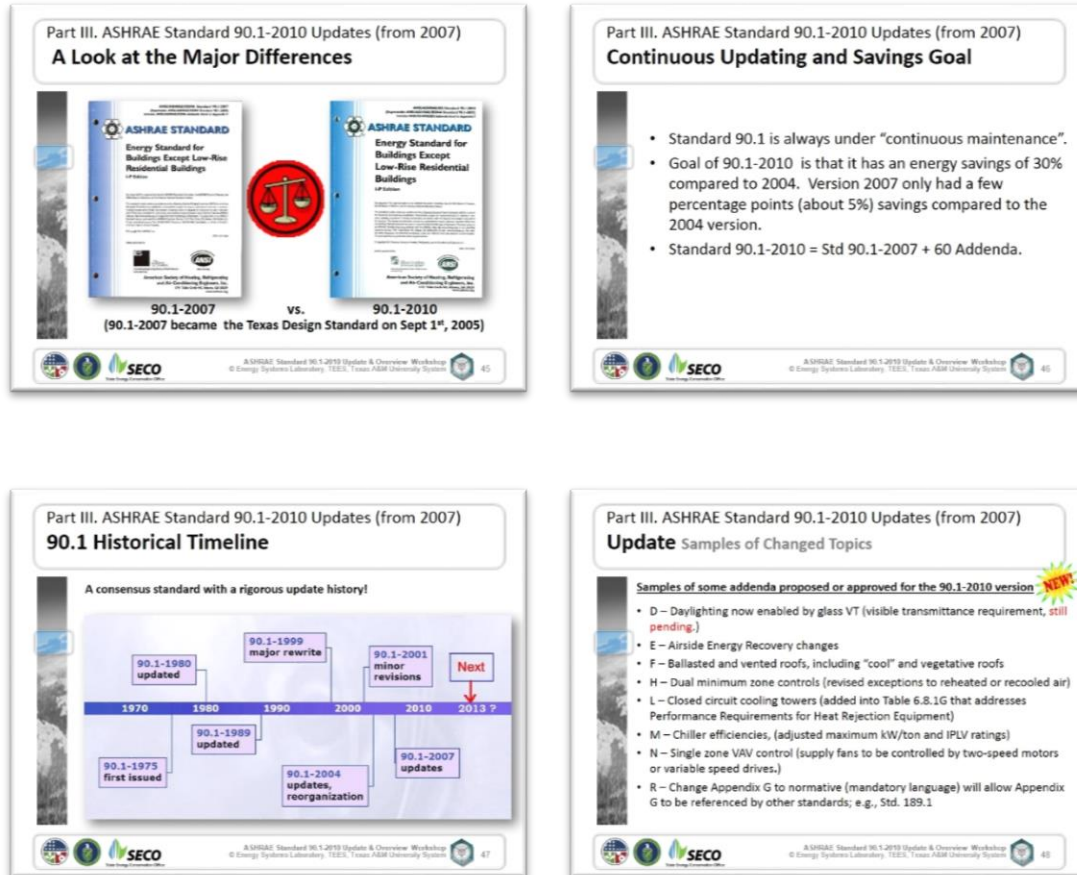
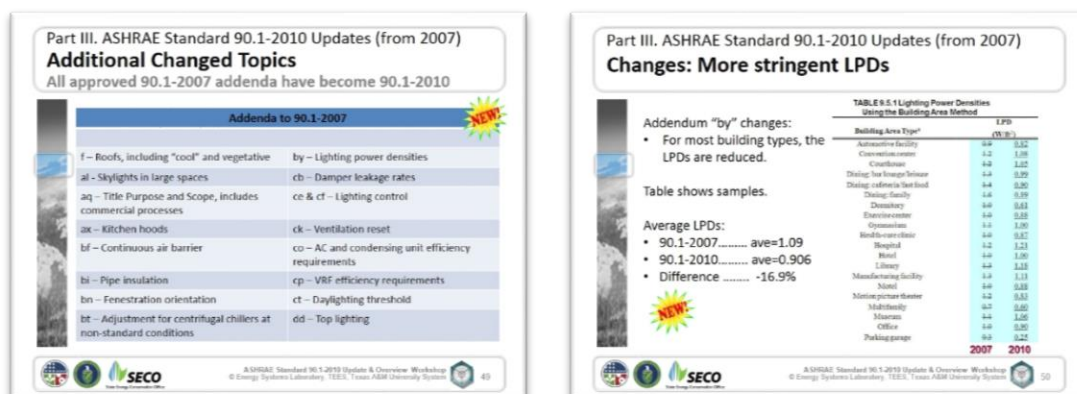


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



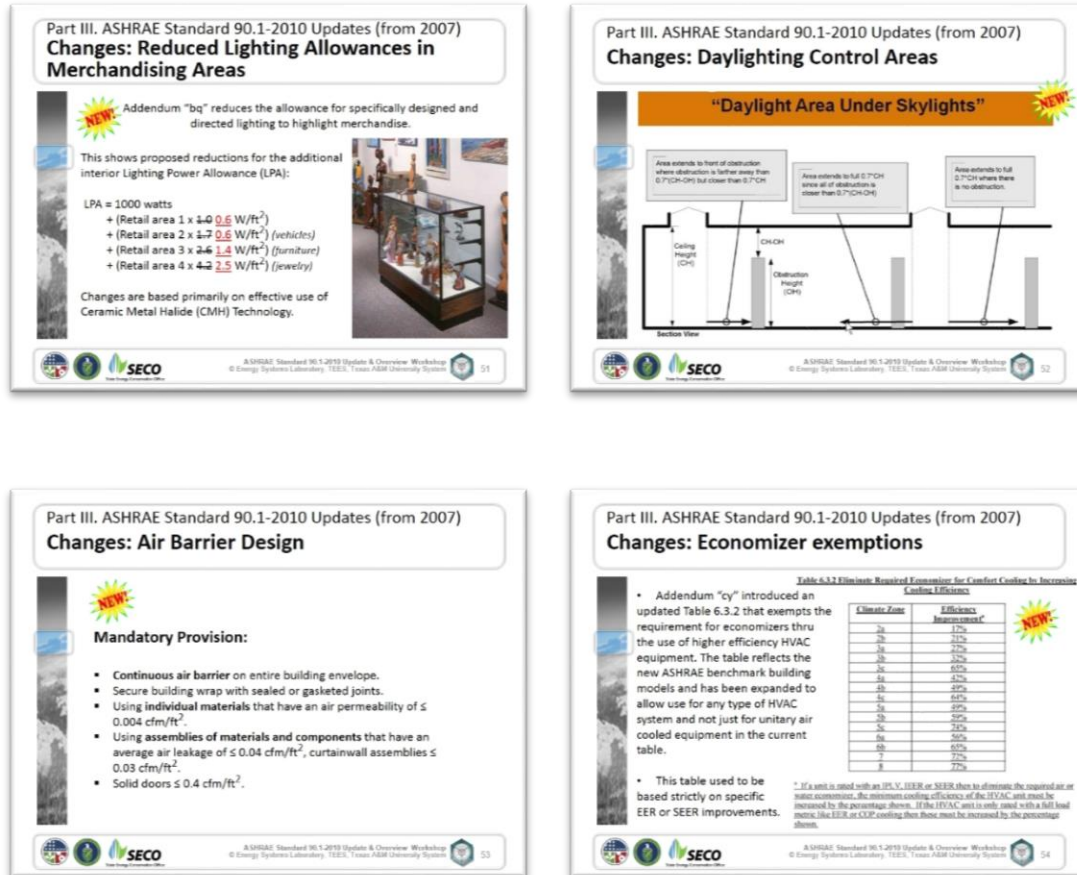


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

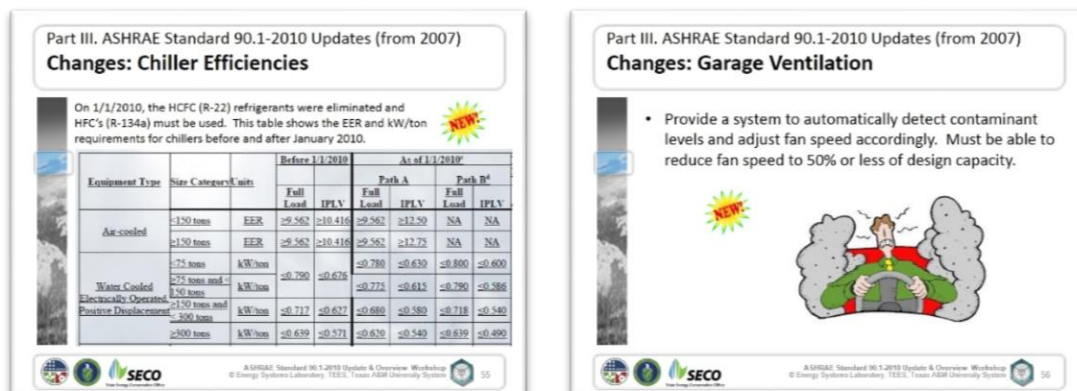
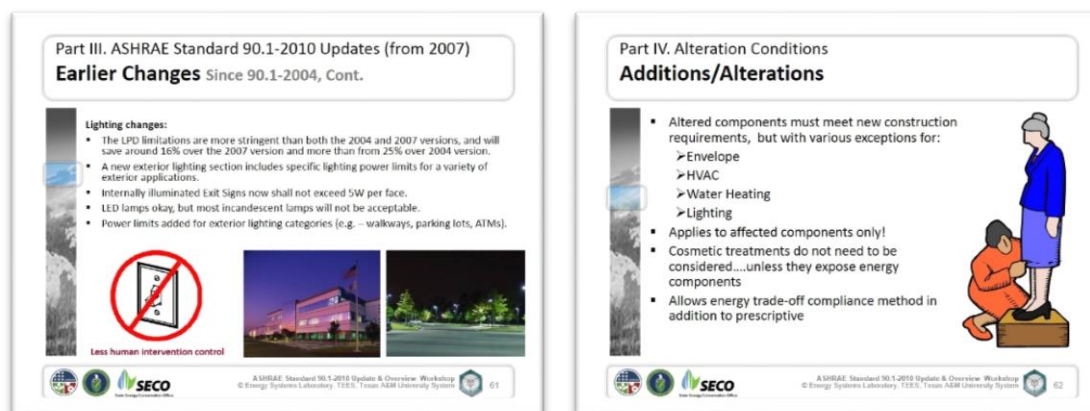






Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



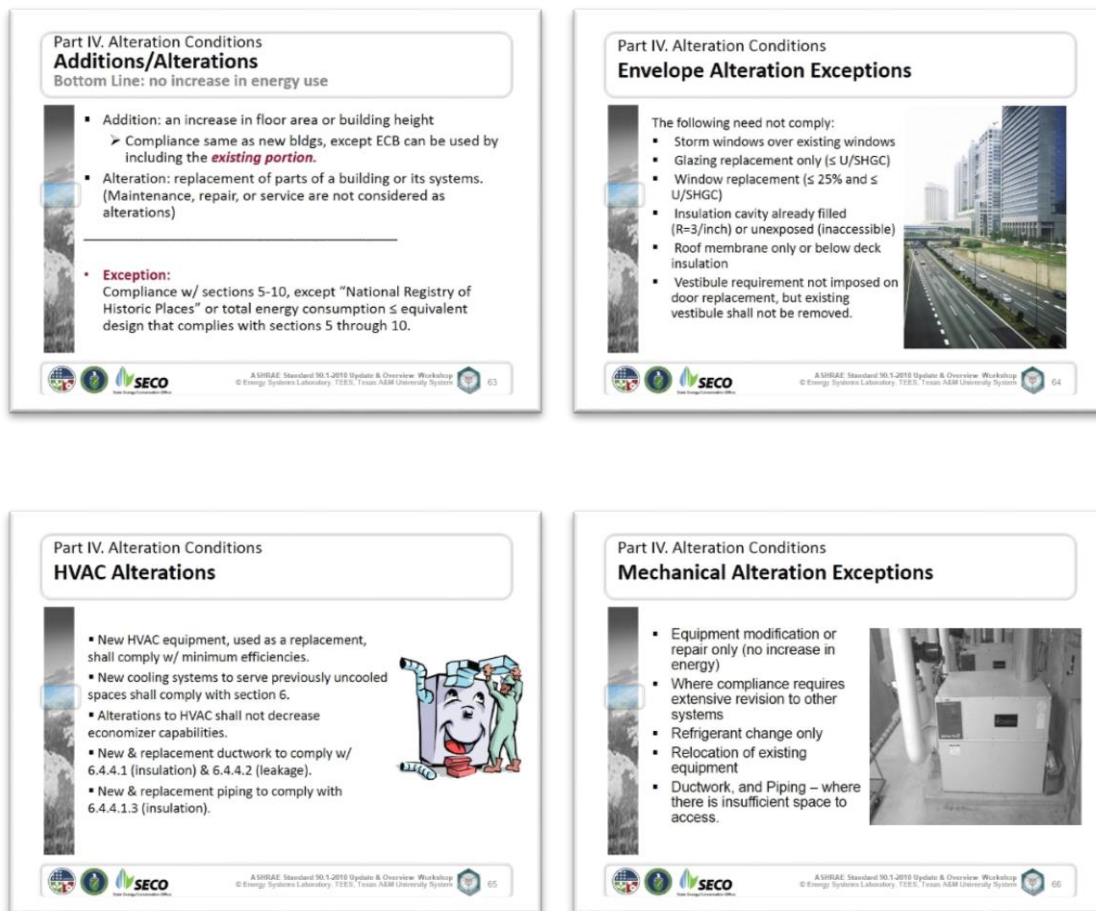
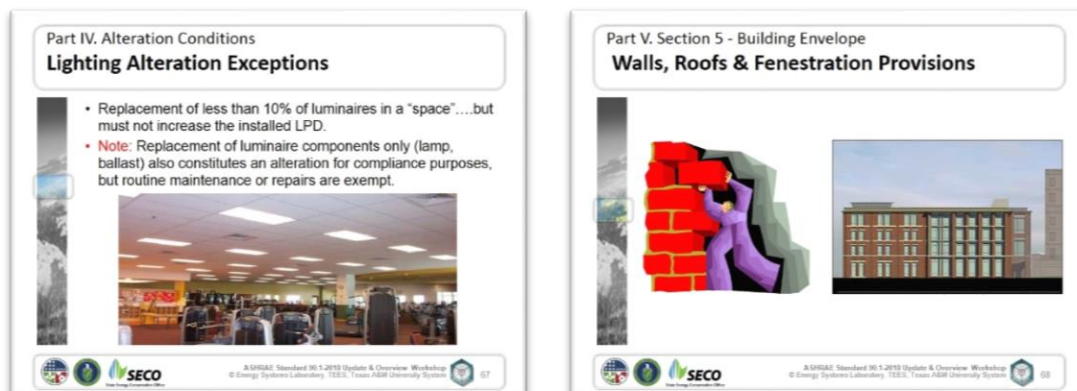


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



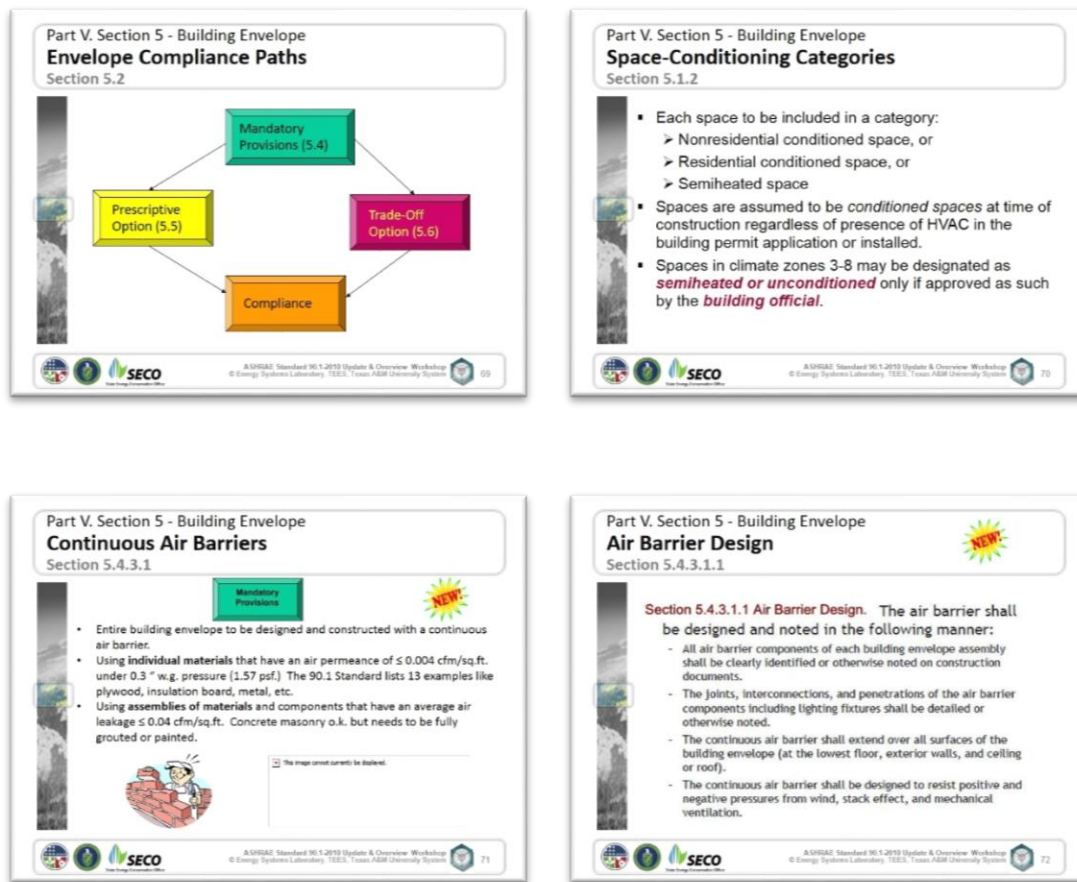
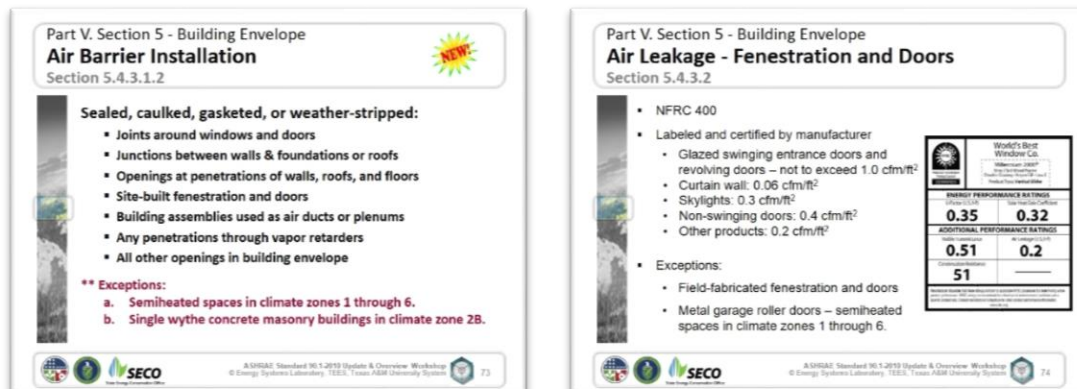


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)







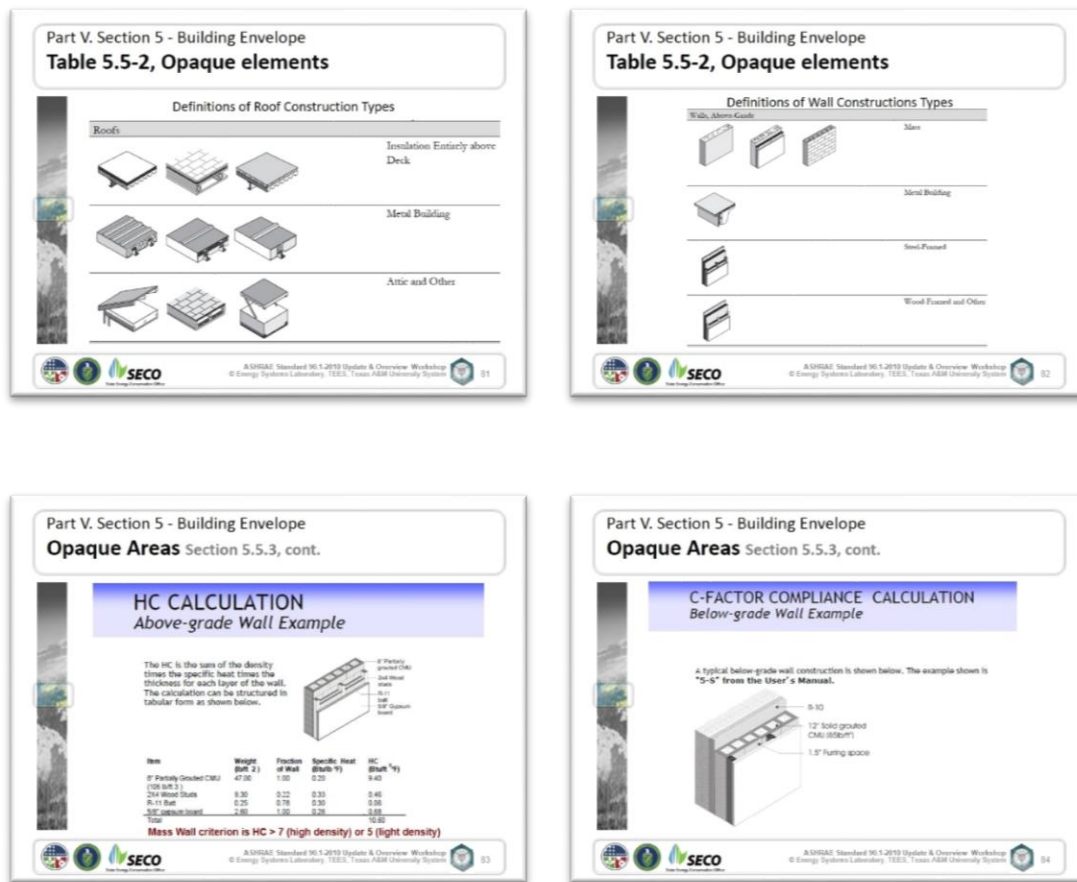
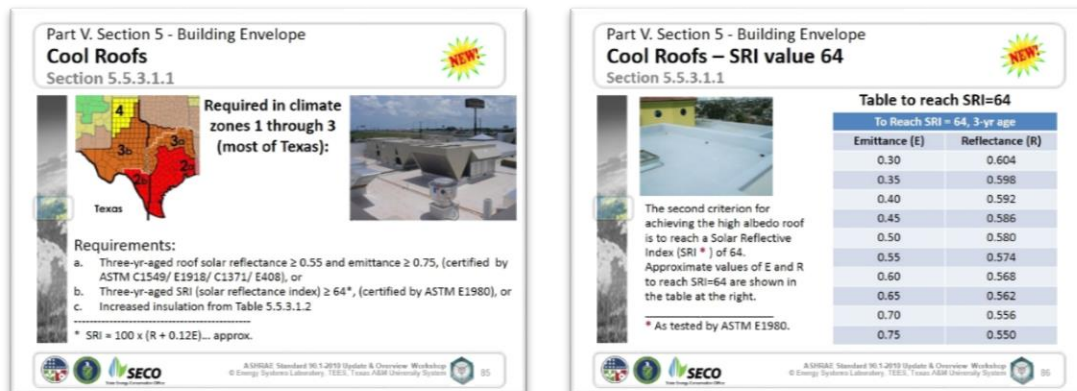


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



**Part V. Section 5 - Building Envelope**  
**Increased Roof Insulation**  
Section 5.5.3.1.1

**NEW**

The third criterion for the Cool Roof requirement is to have increased insulation. (C2.1 through 3)

Roofs	Non-residential		Residential	
Opaque Elements	Assembly Maximum	Insul. Min. R-value	Assembly Maximum	Insul. Min. R-value
Insul. entirely above deck	U-0.030	R-33	U-0.029	R-34
Metal buildings	U-0.028	R-35		

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**Part V. Section 5 - Building Envelope**  
**Cool Roof Exceptions**  
**NEW**

- Stone Ballasted roof at  $\geq 17$  psf.
- Vegetated roof w/  $\geq 2.5"$  soil that covers  $\geq 75\%$  of roof area with growing plants.
- Roofs where  $\geq 75\%$  of roof area:
  - Shaded on June 21 by permanent features, or
  - Covered by solar collectors or solar PV arrays, or
  - Combinations of 1 and 2 above.
- Steep sloped roofs ( $> 2:12$  slope).
- Low sloped ( $\leq 2:12$  slope) metal bldg. roofs in climate zones 2 and 3.
- Roofs over ventilated attics or semi-heated spaces.
- Asphaltic membranes in climate zones 2 and 3.

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**Part V. Section 5 - Building Envelope**  
**Typical Cool Roofs**

With so many exceptions and conditions, what would be the typical roof affected by this requirement?

7-story Apt. Bldg.  
Strip Mall  
Retail Sales  
Medical Offices

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**15-min. Break**

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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

**Part V. Section 5 - Building Envelope**  
**Table 5.5-2 (Fenestration)**  
U.F. & SHGC Requirements in Climate Zone 2 (A, B)

**UF and SHGC \*\* Requirements  $\leq 40\%$  glass**

TABLE 5.5-2 Building Envelope Requirements For Climate Zone 2 (A, B)

Fenestration	Nonresidential		Residential		Lowrise	
	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC
Vertical Glazing, 60%–80% of Wall						
Nonmetal Framing (all)	U-0.75		U-0.75		U-0.75	
Metal Framing (uninsulated/insulated)	U-0.70	SHGC $\leq 0.25$ all	U-0.70	SHGC $\leq 0.25$ all	U-0.70	SHGC $\leq 0.25$ all
Metal Framing (insulated double)	U-1.10		U-1.10		U-1.10	
Metal Framing (all other)	U-0.75		U-0.75		U-0.75	
Roof/Gable with Glass, 10% of Roof						
0%–2.0%	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$
2.1%–5.0%	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$
Roof/Gable with Glass, 10% of Roof						
0%–2.0%	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$
2.1%–5.0%	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$
Roof/Gable with Glass, All % of Roof						
0%–2.0%	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$
2.1%–5.0%	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$	U <sub>glz</sub> $\leq 0.9$	SHGC <sub>glz</sub> $\leq 0.9$

\*\* SHGCs have a major change from 90.1-2004: These now apply to all orientations, including North

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**Part V. Section 5 - Building Envelope**  
**Solar Heat Gain Coefficient (SHGC)**  
Section 5.8.2.5

"The SHGC for the overall fenestration area shall be determined in accordance with NFRC 200."

**Exceptions – one of these alternatives:**

- SC (from NFRC 300)  $\times 0.86$  is acceptable for overall fenestration area.
- SHGC of center of glass (spectral data file per NFRC 300 certified by manufacturer) is acceptable for overall fenestration area.
- SHGC from Table A8.1 for unlabeled skylights.
- SHGC from Table A8.2 for other unlabeled vertical fenestration.

**Notes:**

- NFRC (National Fenestration Rating Council) test procedures:
- 100: U-Factors
- 200: Solar Heat Gain Coefficients (SHGC)
- 300: Solar Optical properties, incl. SC (Shading Coefficient)
- 400: Air leakage rates

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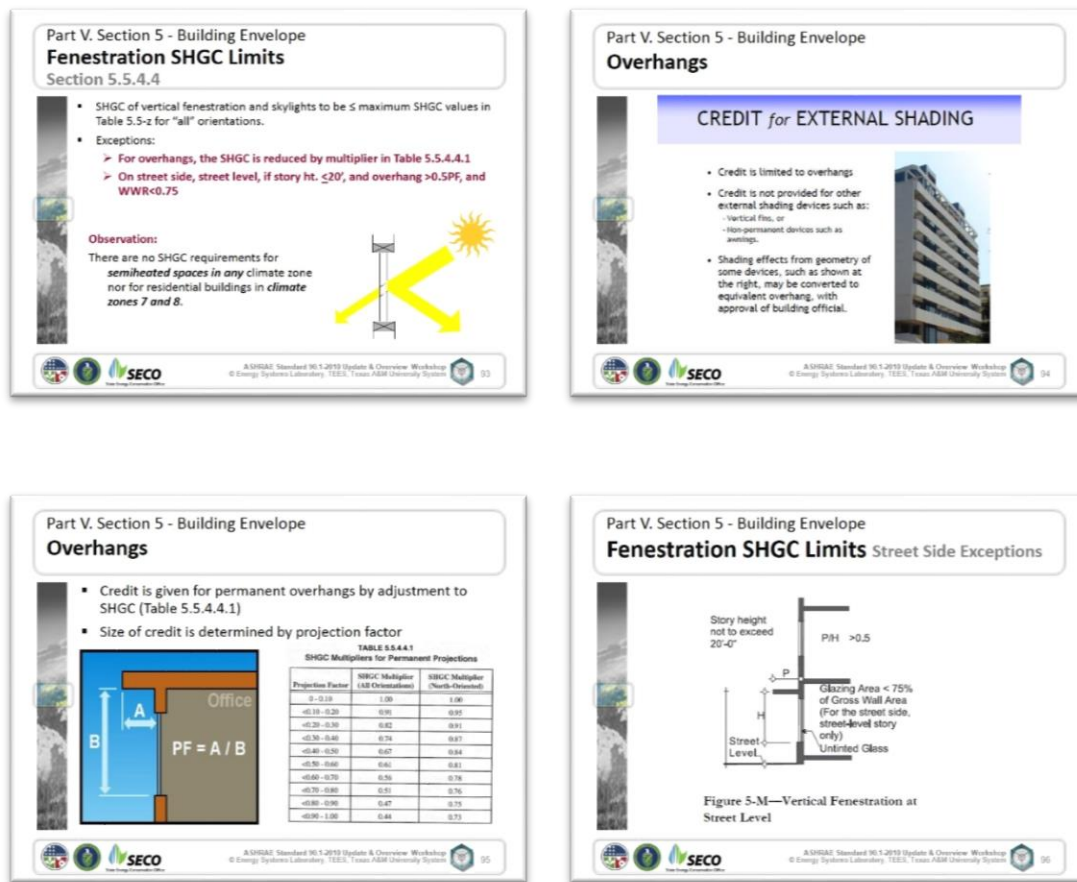
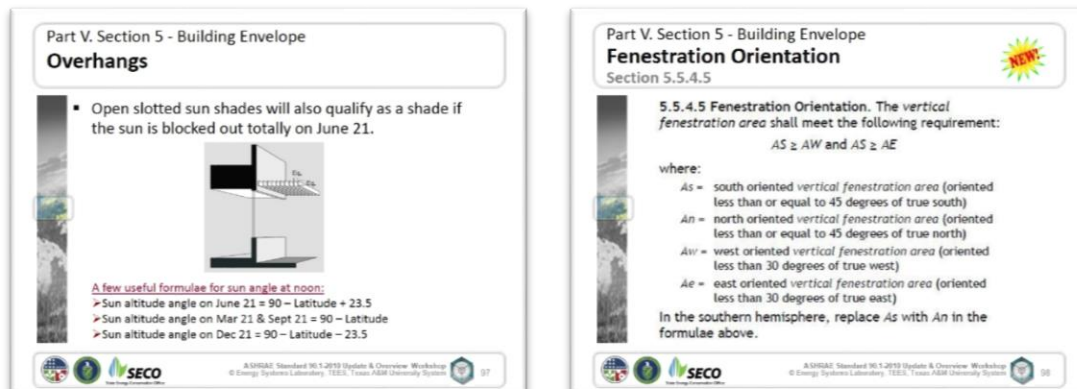


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



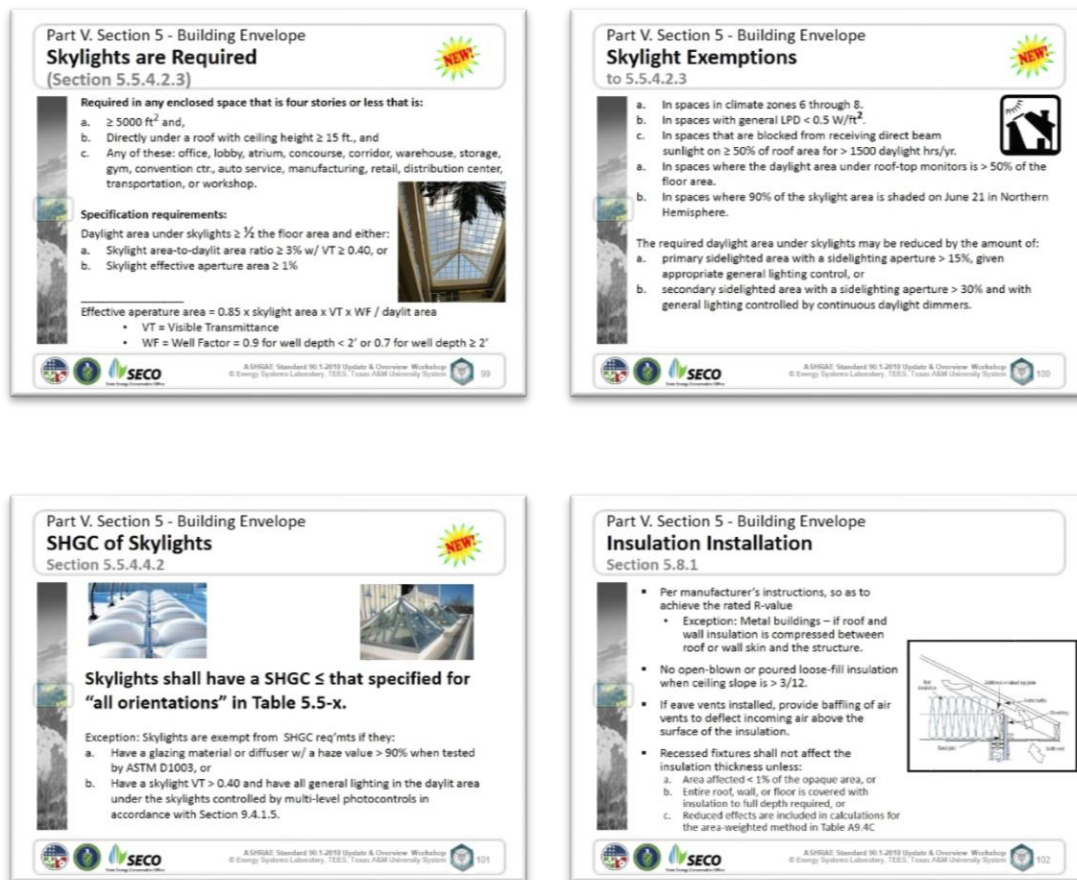
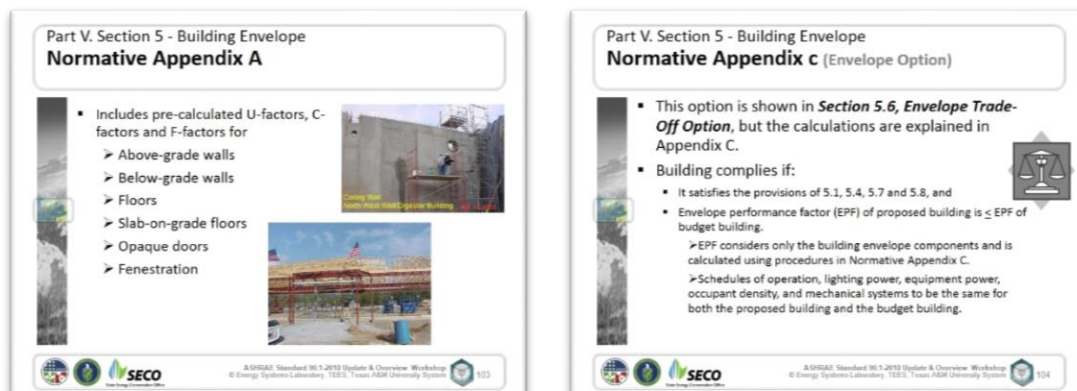


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





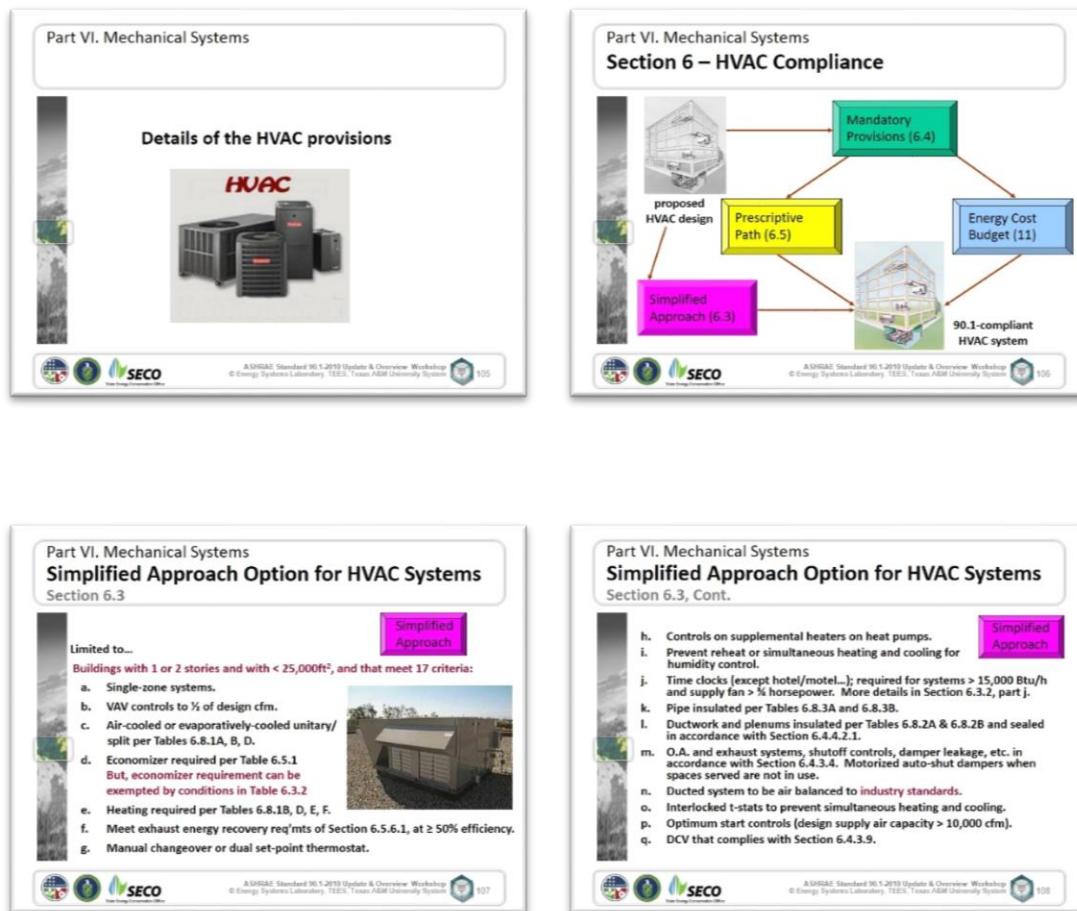
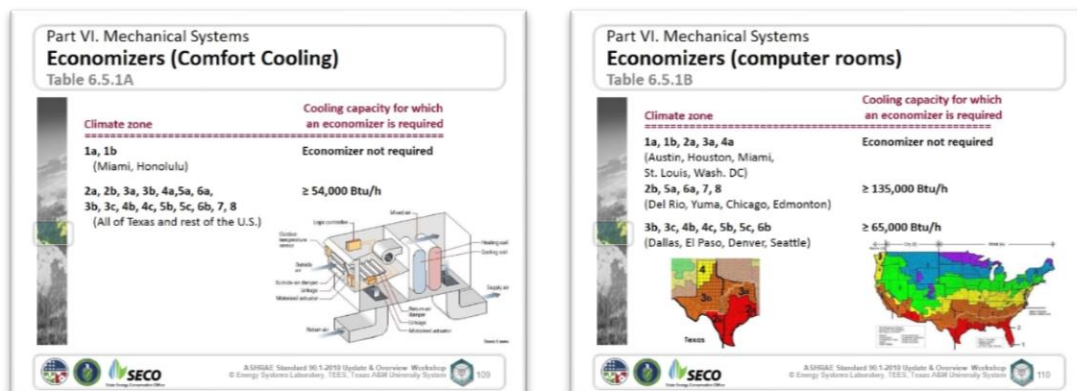


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



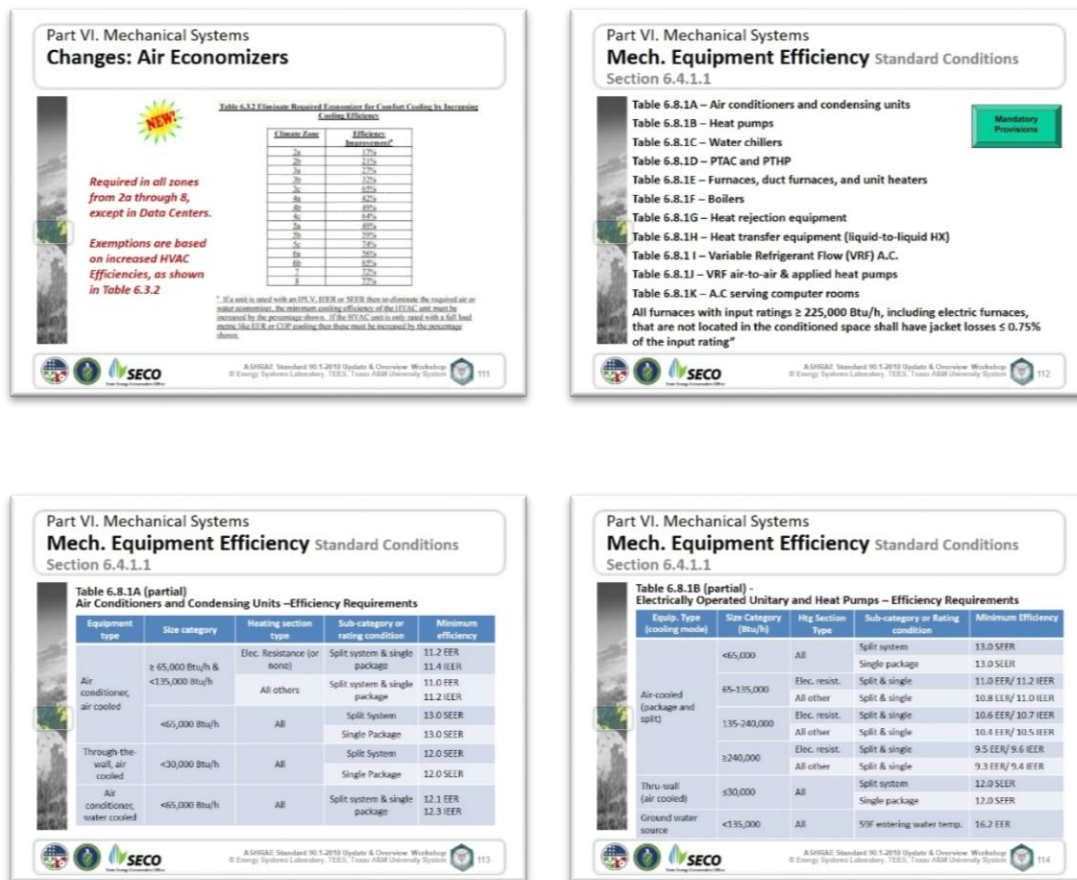
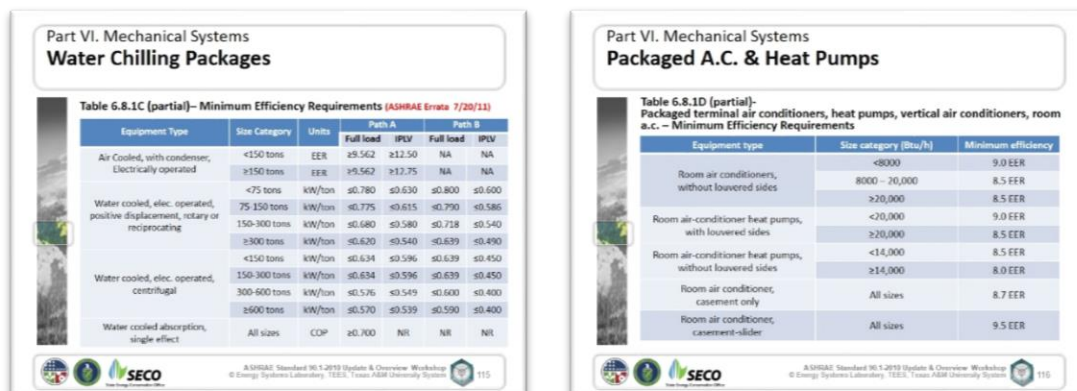


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



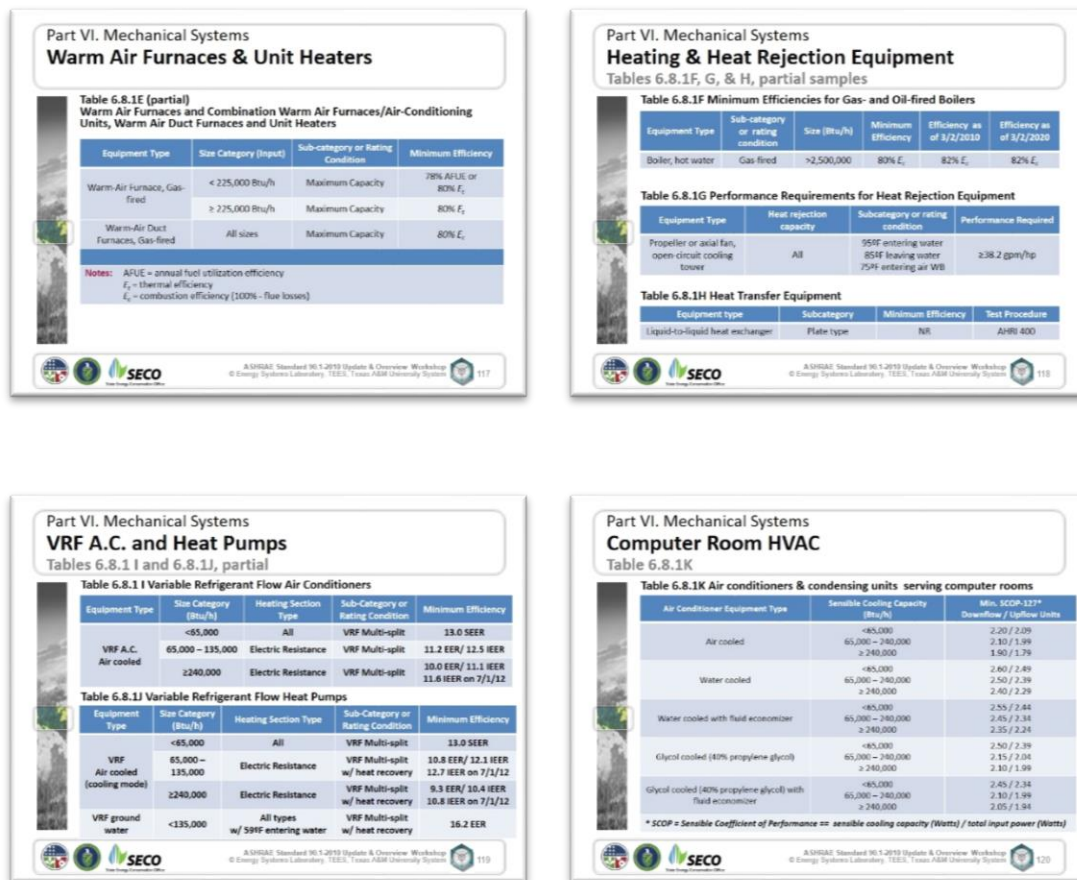


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

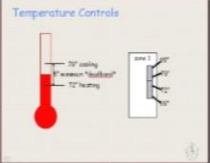


### Part VI. Mechanical Systems

#### Thermostat Dead Band

##### Section 6.4.3.1.2

- Thermostats must have a dead band of at least 5°F.
- Exceptions**
  - Thermostats that require manual changeover between heating and cooling modes.
  - Special occupancy or applications where wide temperature ranges aren't acceptable (e.g., museums, retirement homes) and are approved by adopting authority.




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### Part VI. Mechanical Systems

#### Off-hour Controls

##### Section 6.4.3.3

- HVAC systems shall have the following off-hour controls:
  - automatic shutdown
  - setback controls
  - optimum start controls
  - zone isolation
- Exceptions, HVAC systems:**
  - intended to operate continuously, or
  - having <15,000 Btu/h htg & clg capacity w/ manual on-off controls.




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### Part VI. Mechanical Systems

#### Automatic Shutdown

##### Section 6.4.3.3.1

- Controls to operate on different time schedules for seven different day-types per week (residential may have just two schedules) and retain programming and time setting during loss of power for at least 10 hrs, or
- An occupant sensor, or
- A manually-operated timer with maximum two hour duration, or
- An interlock to security system that shuts the system off when security is activated.



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### Part VI. Mechanical Systems

#### Setback Controls

##### Section 6.4.3.3.2

- Applies to heating systems located in climate zones 2 – 8, with heating set point adjustable to 55°F.
- Applies to cooling systems in climate zones 1b, 2b, & 3b, with set point adjustable to at least 90°F, or to prevent high space humidity levels.
- Exception**
  - “Radiant floor and ceiling heating systems”

**Note:** There is no climate zone “1b” in the U.S.



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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

### Part VI. Mechanical Systems

#### Optimum Start Controls

##### Section 6.4.3.3.3

- Individual heating and cooling air distribution systems with total design supply air capacity > 10,000 cfm.
- Control algorithm to at least “be a function of difference between space temperature and occupied setpoint and amount of time prior to scheduled occupancy.”




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### Part VI. Mechanical Systems

#### Ventilation Shutoff Damper Controls

##### Section 6.4.3.4.2

- All o.a. intake & exhaust systems shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use.
- Exceptions:**
  - Gravity dampers o.k. in bldgs:
    - < 3 stories in height above grade.
    - All bldgs in climate zones 1, 2, and 3.
  - Gravity dampers o.k. in systems with a design o.a. intake of ≤300 cfm.
  - Dampers not required in Ventilation systems serving unconditioned spaces
  - Dampers not required in systems serving Type 1\* kitchen hoods.



\* Type 1 is for exhausting air from cooking equipment that produces heat and grease laden effluent.

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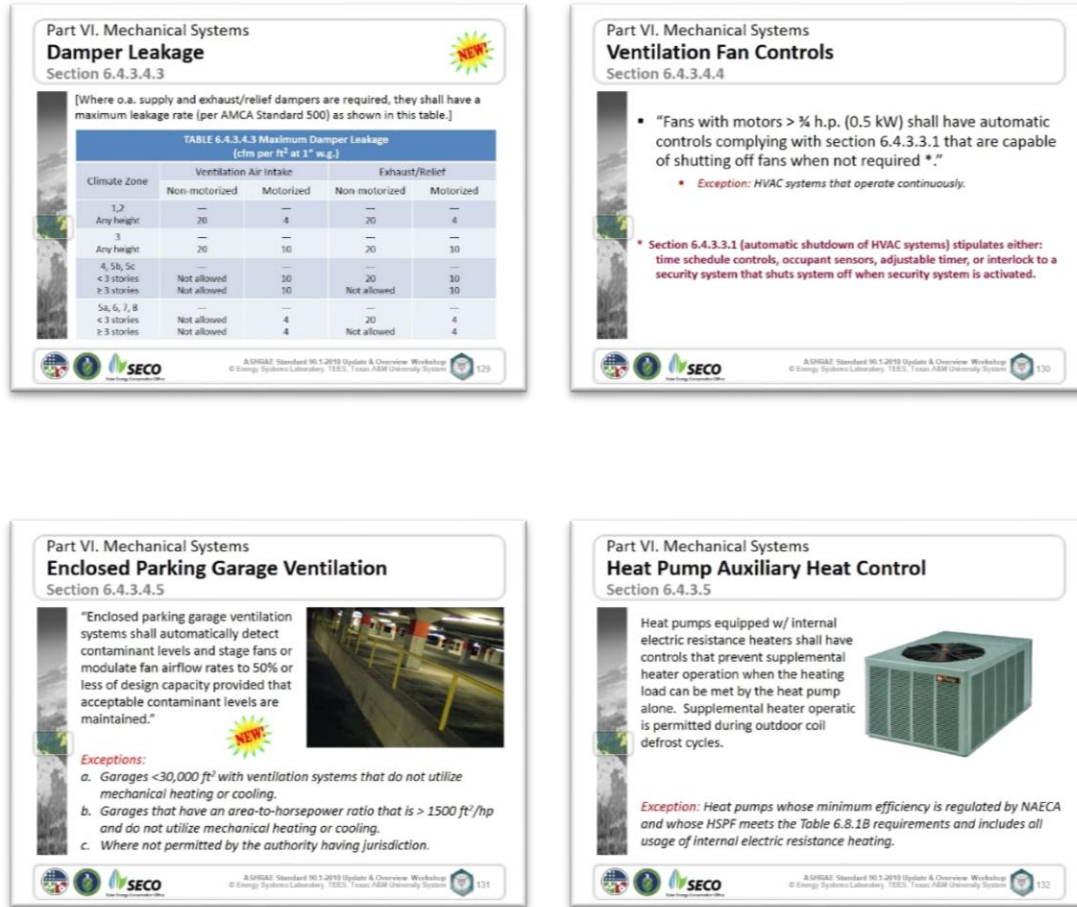
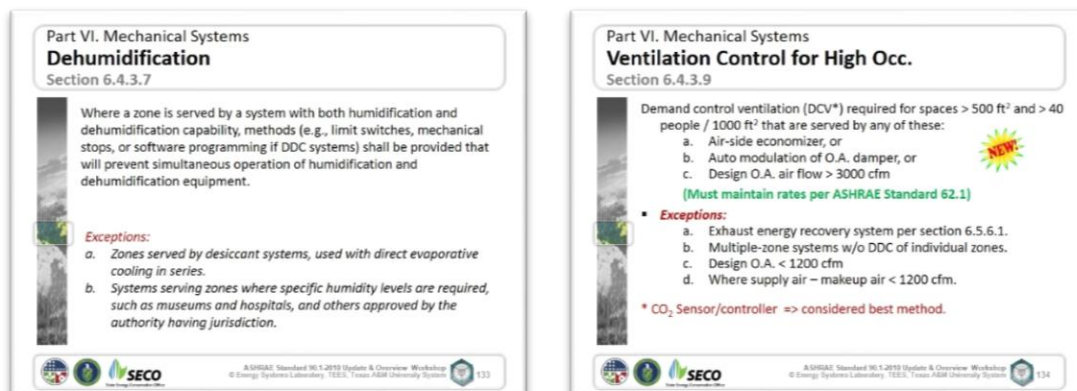




Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



**Part VI. Mechanical Systems**  
**Duct & Plenum Insulation**  
Section 6.4.4.1.2



- All supply and return ducts and plenums to be insulated per Tables 6.8.2A and 6.8.2B
- Four exceptions (next slide)

**Part VI. Mechanical Systems**  
**Duct & Plenum Insulation**  
Section 6.4.4.1.2

**Four exceptions:**

- Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment
- Ducts or plenums located in heated, semi-heated, or cooled spaces
- For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5
- Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft<sup>2</sup> need not exceed R-2; those ≤ 5 ft<sup>2</sup> need not be insulated

**Part VI. Mechanical Systems**  
**Min. Duct Insulation R-value**  
Table 6.8.2B

(For heating and cooling combo ducts)

Climate Zone	Duct Location						
	Exterior	Ventilated attic	Unvented attic above insul. clg.	Unvented attic w/ roof insulation	Un-conditioned space	Indirectly conditioned space	Buried
1	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
4	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
5	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
6	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
7	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
8	R-8	R-8	R-8	R-1.9	R-6	none	R-6
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none

**Part VI. Mechanical Systems**  
**Piping Insulation**  
Section 6.4.4.1.3

- Must meet requirements in Tables 6.8.3A & 6.8.3B.
  - Minimum pipe insulation thickness based on fluid design operating temperature range, insulation conductivity, nominal pipe or tube size, and system type (Heating, SWH, Cooling)
- Exceptions:
  - Factory-installed piping within HVAC equipment.
  - Piping conveying fluids between 60°F and 105°F
  - Piping conveying fluids not heated or cooled with purchased energy (such as roof & condensate drains, nat. gas piping, etc.)
  - Where heat gains or losses will not increase energy use (such as the case with liquid refrigerant piping.)
  - Strainers, control & balancing valves in pipes ≤ 1" diameter.




Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

**Part VI. Mechanical Systems**  
**Duct Sealing**  
Section 6.4.4.2.1

- Ductwork and all plenums with pressure class ratings shall include sealing of all transverse joints, longitudinal seams, and duct wall penetrations.
- Meet requirements of 6.4.4.2.2 (leakage tests).
- Standard industry practice as defined in Appendix E.
- Duct tape or other pressure-sensitive tape shall not be used as the primary sealant unless certified to comply with UL-181A or UL-181B by an independent testing laboratory.




**Part VI. Mechanical Systems**  
**Duct Leakage Tests**  
Section 6.4.4.2.2

- For ductwork designed > 3 in. w.c. and all ductwork located outside:
  - Leak tested per standards in Appendix E.
  - Representative sections ≥ 25% of the total installed duct area shall be tested.
  - Duct ratings that are > 3 in. w.c. to be identified on drawings.
  - Maximum permitted duct leakage shall be calculated and specified, per next slide --



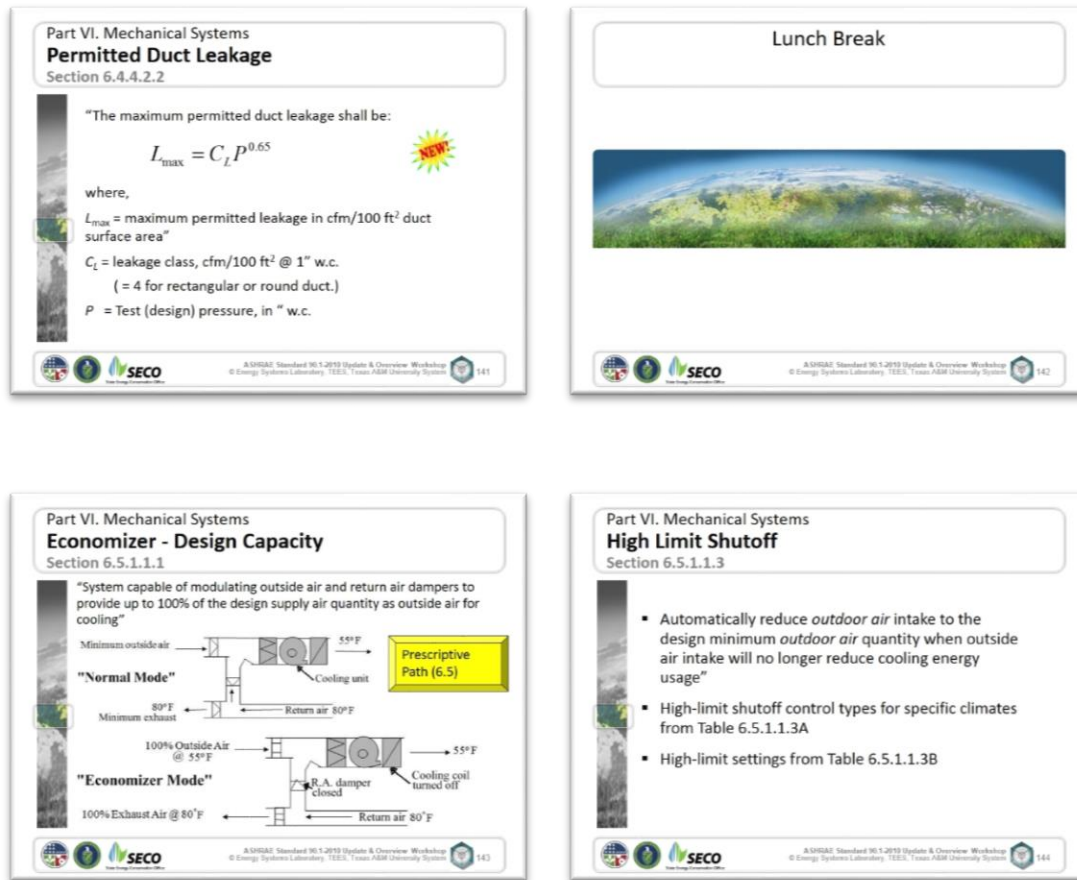
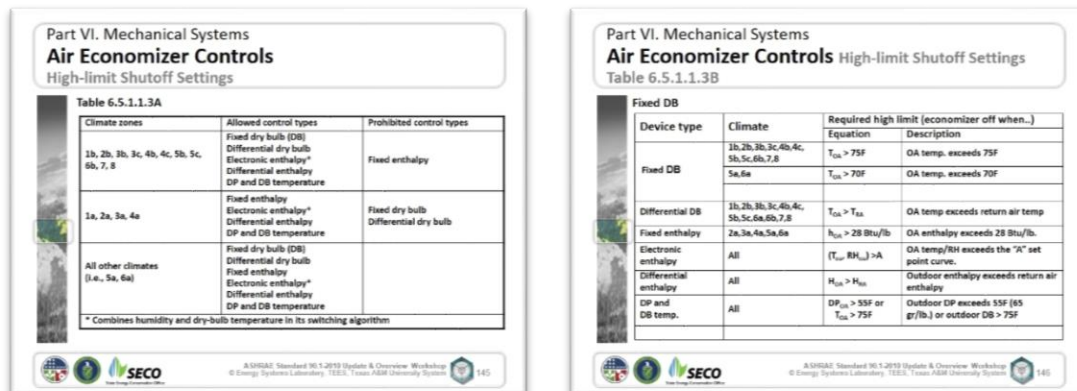


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





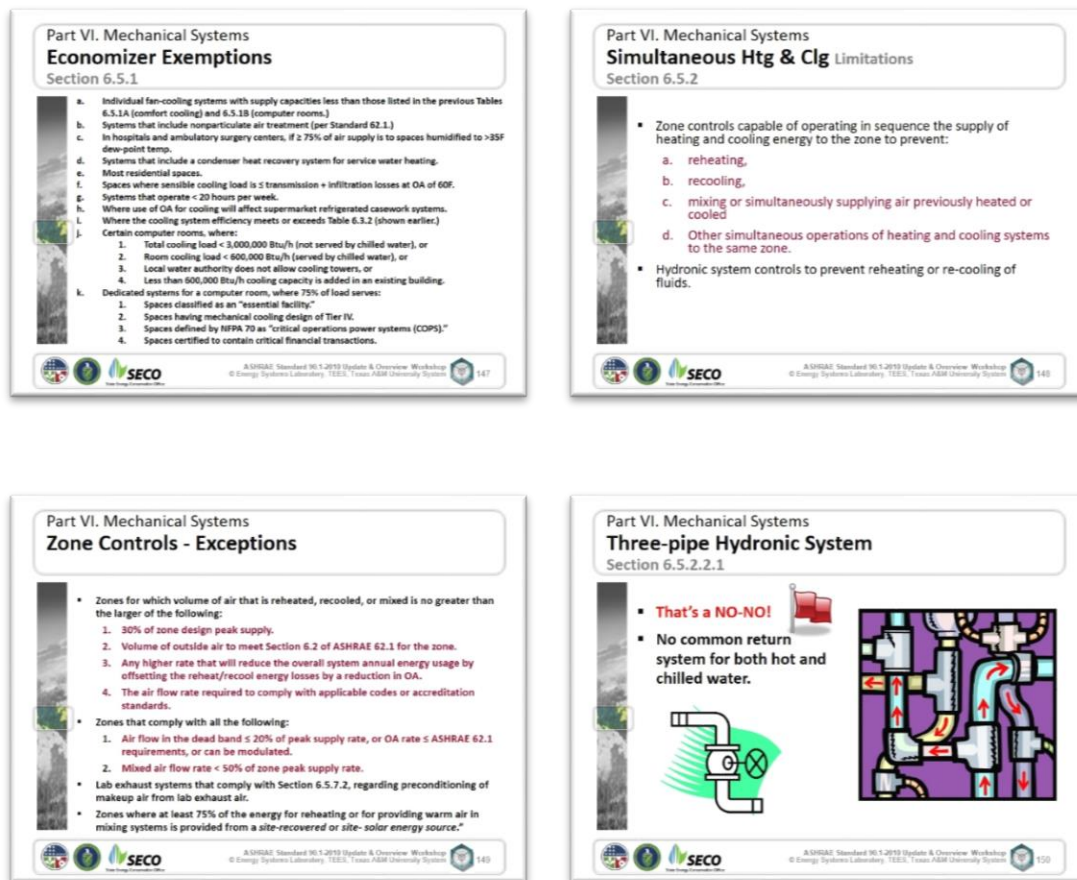


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

## Part VI. Mechanical Systems

# Fan Power Limitation

### Options 1 & 2, Section 6.5.3.1.1



**Table 6.5.3.1.1A Fan Power Limitation #**

Option	Limit	Constant Volume	Variable Volume
1	Allowable Nameplate hp	$hp \leq CFM_x \times 0.0011$	$hp \leq CFM_x \times 0.0015$
2	Allowable Fan system blhp	$blhp \leq CFM_x \times 0.00094 + A^*$	$blhp \leq CFM_x \times 0.0013 + A^*$

\* Adjustment (A) =  $\sum (PD_i \times CFM_i / 4131)$ , where:  
 PD<sub>i</sub> = pressure drop ("w.c.) across fan system for each "i" component in Table 6.5.3.1B (next slide), and  
 CFM<sub>i</sub> = CFM through component "i"


# Compute "installed blhp" =  $\sum (PD_i \times CFM_i / (6356 \times \eta))$ , where:  
 PD<sub>i</sub> = pressure drop ("w.c.) across fan system "i"  
 CFM<sub>i</sub> = CFM of fan system "i"  
 η<sub>i</sub> = efficiency of fan system "i" (assumed to be 0.65 allowable limits)

**Footnote:** This methodology was first introduced in Standard 90.1-2007, though with different adjustment values.

ASHRAE Standard 90.1-2013 Update & Overview Workshop

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Part VI. Mechanical Systems	
Fan Power Limitation	
Option 2 - Section 6.5.3.1.1	
Table 6.5.3.1.1B for the brake horsepower (bhp) option 2 Adjustment Factors (A)	
TABLE 6.5.3.1.1B for the bhp	Fan Power Limitation Pressure Drop Adjustment
Device	Adjustment
<p><b>Condits</b></p> <p>Fully ducted return exhaust air systems</p> <p>Return exhaust without return air systems</p> <p>Exhaust filters, condenses, or other exhaust treatment</p> <p>Purification Filtration Device (MEDV) through 12</p> <p>Purification Filtration Device (MEDV) 13 through 15</p> <p>Periodic Filtration Device (MEDV) in general and electrically reduced systems</p> <p>Carbon and other gas-phase air cleaners</p> <p>Biocidal cabinet</p> <p>Energy Recovery Device, either or Coil Returnment Loop</p> <p>Coil Returnment Loop</p> <p>Respiratory humidification in series with another cooling coil</p> <p>Sound Attenuation Section</p> <p>Exhaust air systems serving farm foods</p> <p>Laboratory and vibration exhaust systems in high-rise buildings</p>	<p>0.5 w.e. w.e. 0.25 in. w.e. for laboratory and vibration systems</p> <p>0.5 in. w.e.</p> <p>The pressure drop of devices calculated at the system design condition</p> <p>0.5 in. w.e.</p> <p>0.5 in. w.e.</p> <p>Pressure drop calculated at 27° clean filter pressure drop at the system design condition</p> <p>Clean filter pressure drop at the system design condition</p> <p>Pressure drop of device at fan system design condition</p> <p>(2.7 × Energy Recovery Efficiency) - 0.5 in. w.e. for each unit</p> <p>0.5 in. w.e. for each unit</p> <p>Pressure drop of device at the system design condition</p> <p>0.15 in. w.e.</p> <p>0.15 in. w.e.</p> <p>0.25 in. w.e. 100 ft. of vertical duct exceeding 70 ft</p>

Part VI. Mechanical Systems

## Part-load Fan Power Limitation

Section 6.5.3.2.1

- Individual VAV fans with motors  $\geq 10$  hp \*
  - Shall have VSD, or
  - Shall be vane-axial w/ variable pitch blades, or
  - Shall have other controls and devices to result in fan motor demand  $\leq 30\%$  of design wattage at 50% of design air volume when static pressure set point =  $1/3$  of total design static pressure, based on *manufacturer's* certified fan data.
- \* Was 30 hp in 90.1-2001 and 15 hp in 90.1-2004.



## Part VI. Mechanical Systems

# Exhaust Air Energy Recovery

### Section 6.5.6.1

- ★ Incorporate exhaust air energy recovery systems with at least 50% enthalpy energy recovery effectiveness.

**Table 6.5.6.1 Exhaust Air Energy Recovery Requirements**

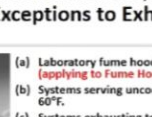
Climate Zone	% Outdoor Air at Full Design Airflow Rate				
	30-40%	40-50%	60-70%	70-80%	> 80%
	Design Supply Fan Airflow Rate (cfm)				
3b,c,4b,c,5b	NR	NR	NR	NR	>5000
1b,2b,5c	NR	NR	≥16000	≥12000	≥5000
6b	≥11000	≥5500	≥3500	≥3500	≥1500
1a-6a	≥1500	≥4500	≥3500	≥2000	≥1000
7,8	≥2500	≥1000	≥0	≥0	≥0

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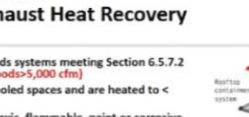
Figure 24: SHRAE 90.1 Standard Update Workshop (continued)

Part VI. Mechanical Systems

## Exceptions to Exhaust Heat Recovery



- (a) Laboratory fume hoods systems meeting Section 6.5.7.2 (applying to Fume Hoods >5,000 cfm)
- (b) Systems serving uncooled spaces and are heated to < 60°F.
- (c) Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
- (d) Commercial kitchen hoods for collecting and removing grease vapors and smoke.
- (e) Where > 60% of outdoor air heating energy is provided from site-recovered or site-solar energy
- (f) Heating systems in climate zones 1 and 2.
- (g) Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, & 8.
- (h) Where largest single exhaust source is < 75% of the design outdoor air flow.
- (i) Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
- (j) Systems in Table 6.5.6.1 that operate < 20 hrs/week.

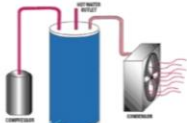


## Part VI. Mechanical Systems

### Heat Recovery for SWH

#### Section 6.5.6.2

- Condenser recovery required for service water heating if:
  - Used 24 hrs per day and
  - Heat rejection > 6,000,000 Btu/h (approx. 375 tons) and
  - SWH load > 1,000,000 Btu/h

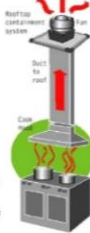


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### Part VI. Mechanical Systems Laboratory Exhaust Systems Section 6.5.7.2


Buildings with laboratory exhaust systems having > 5000 cfm exhaust shall have at least one of the following features:

- System shall be capable of reducing exhaust and makeup air flow rates and/or incorporate a heat recovery system to precondition the makeup air from the laboratory that meets this effectiveness percentage equation:  $A + B \times (E/M) \geq 50\%$ , where:  
 A = % airflow rates can be reduced from design.  
 B = % sensible heat recovery effectiveness.  
 E = design exhaust airflow rate.  
 M = design makeup airflow rate.
- VAV laboratory systems that have regulated minimum circulation rates shall be capable of reducing zone exhaust and makeup rates to that minimum rate or to the rate to assure proper pressurization. Non-regulated zones shall be capable of reducing the exhaust rates to 50% of the design values.



### Part VI. Mechanical Systems Completion Requirements Section 6.7.2


- Record drawings
- Operating and maintenance manuals
- System balancing
- System commissioning



### Part VI. Mechanical Systems Record Drawings Section 6.7.2.1

Record drawings of actual installation to building owner within 90 days of system acceptance and include, as a minimum:

- Location and performance data on each piece of equipment
- General configuration of duct and pipe distribution system including sizes
- Terminal air or water design flow rates



### Part VI. Mechanical Systems Manuals Section 6.7.2.2

Operating and maintenance manuals to building owner within 90 days of system acceptance and include, as a minimum:

- Equipment size and selected options
- Operation manuals for each piece of equipment requiring maintenance with actions clearly identified.
- Names & address of at least one service agency.
- HVAC Control system maintenance information.
- A complete narrative of how each system is intended to operate.




Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

### Part VI. Mechanical Systems System Balancing Section 6.7.2.3

- HVAC systems balanced in accordance with standards in Appendix E.
- Written report for conditioned spaces > 5000 ft<sup>2</sup>.

### Part VI. Mechanical Systems System Commissioning Section 6.7.2.4

- "Ensure that control elements are calibrated, adjusted, and in proper working condition."
- In plans and specs, provide detailed instructions for commissioning of projects > 50,000 ft<sup>2</sup> of conditioned area.
  - Except warehouses and semiheated spaces.

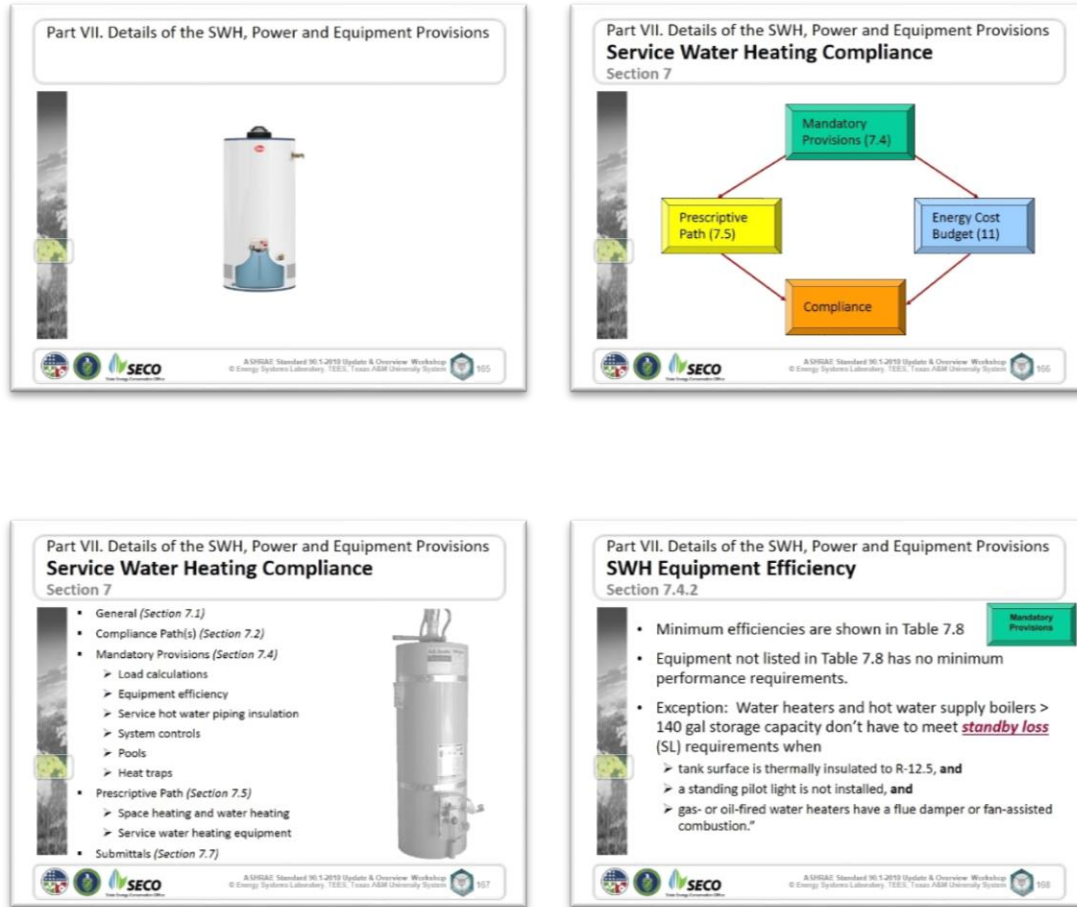
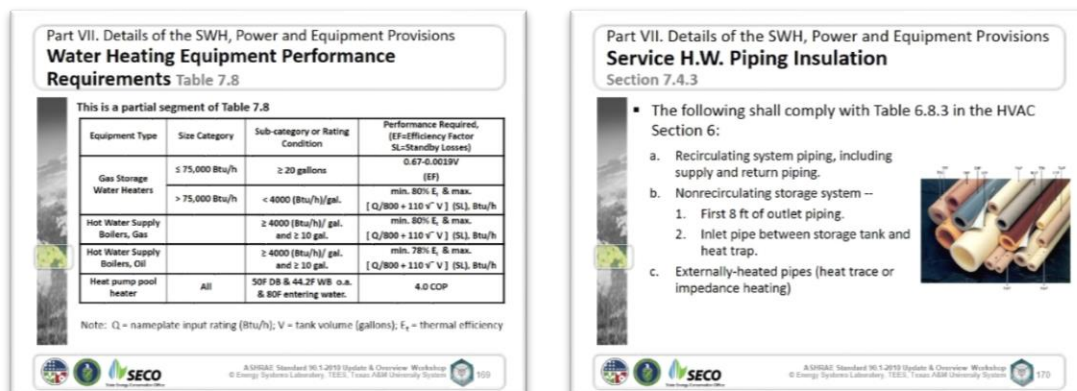


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





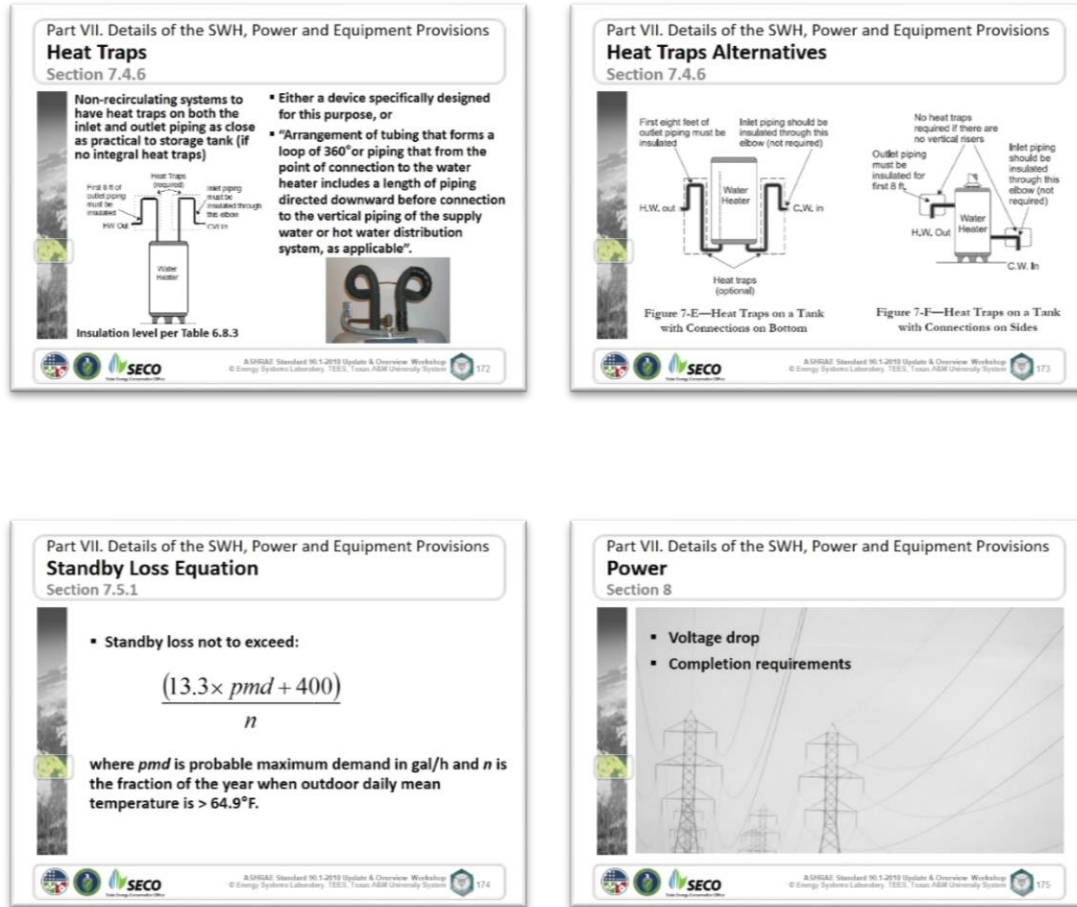
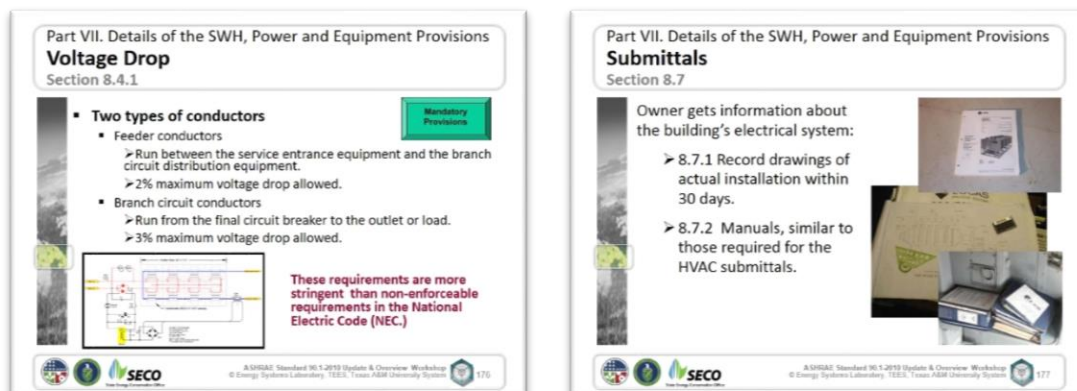
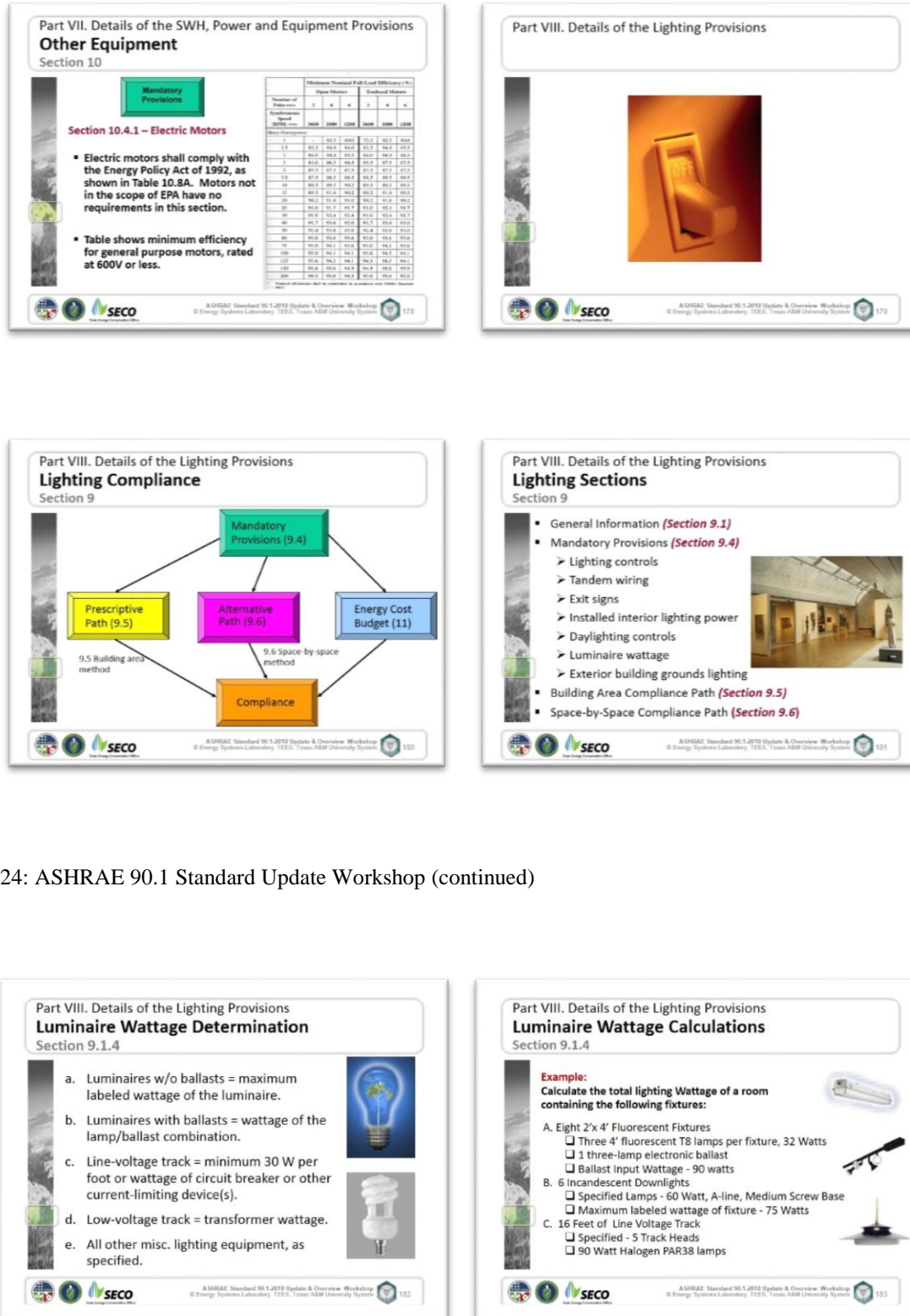


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





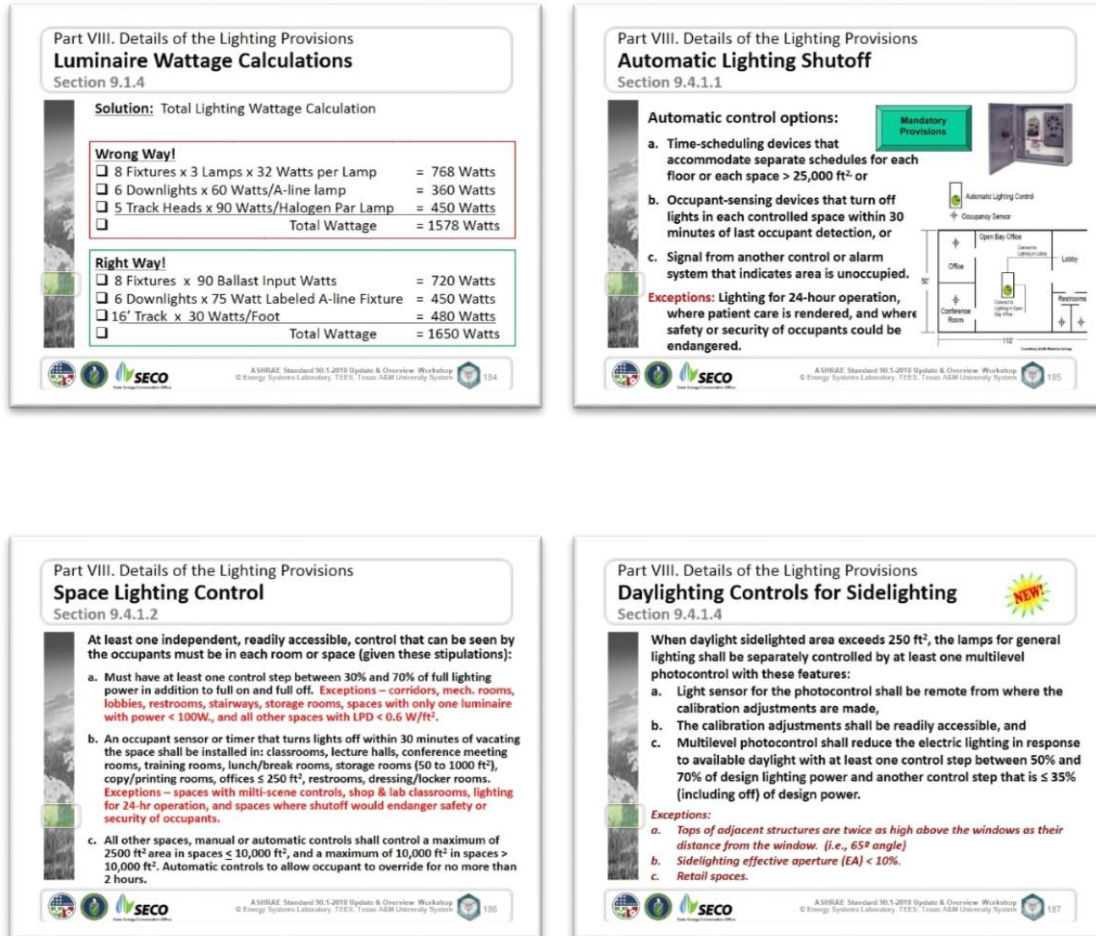


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





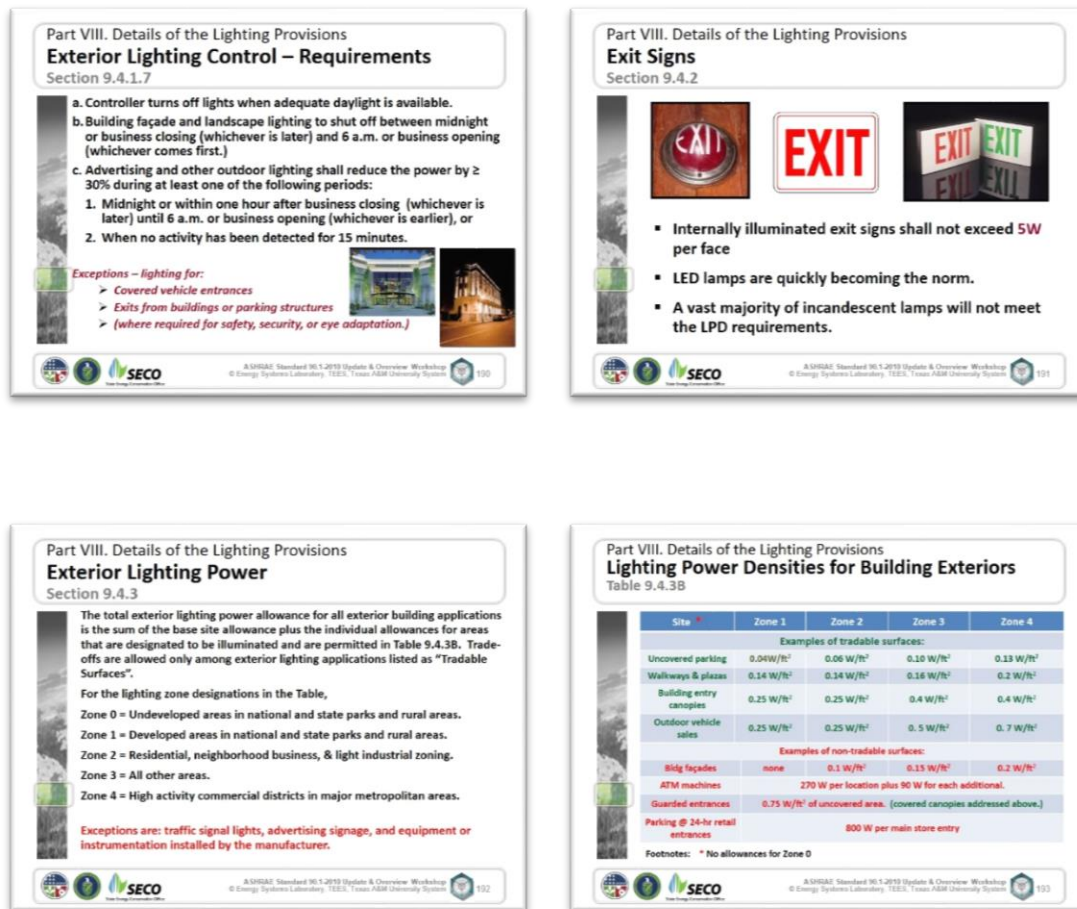
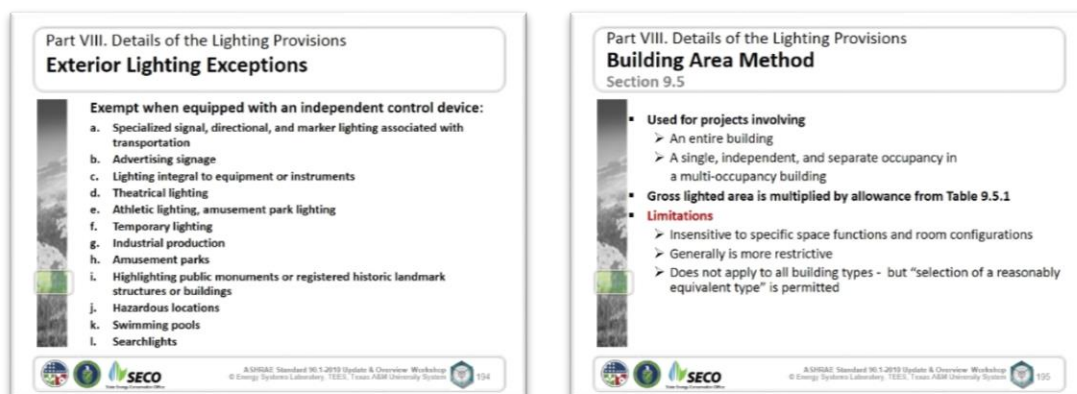


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



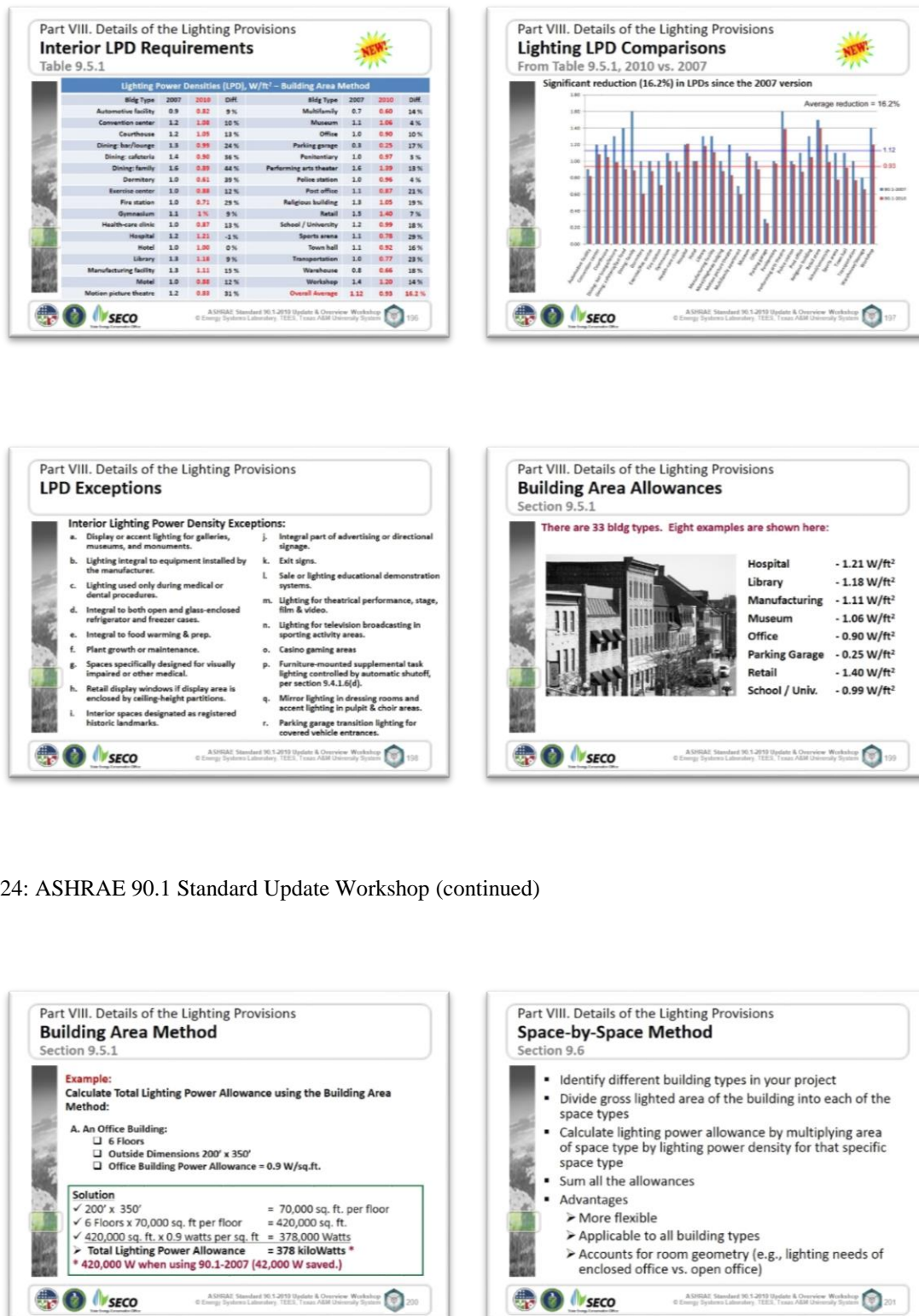



Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

Part VIII. Details of the Lighting Provisions  
**Space-by-Space Method**  
Section 9.6.1

There are 95 space types. Eleven examples are shown here:



**Office Building Spaces:**

Office Enclosed	- 1.11 W/ft <sup>2</sup>
Office Open	- 0.98 W/ft <sup>2</sup>
Conference	- 1.23 W/ft <sup>2</sup>
Training	- 1.24 W/ft <sup>2</sup>
Lobby	- 0.90 W/ft <sup>2</sup>
Lounge	- 0.73 W/ft <sup>2</sup>
Dining	- 0.65 W/ft <sup>2</sup>
Food Prep.	- 0.99 W/ft <sup>2</sup>
Corridor	- 0.66 W/ft <sup>2</sup>
Restroom	- 0.98 W/ft <sup>2</sup>
Active Storage	- 0.63 W/ft <sup>2</sup>


Part VIII. Details of the Lighting Provisions  
**Additional Interior Lighting Power**  
Section 9.6.2

Additional interior lighting power is allowed for specific space functions when using the space-by-space method:

a. Decorative – 1.0 W/ft<sup>2</sup> in space used

b. Lighting equipment installed in retail spaces specifically to highlight merchandise in specific space used, as follows:

- Sales area for general consumer goods, 0.6 W/ft<sup>2</sup>
- Vehicles, sporting goods, small electronics, 0.6 W/ft<sup>2</sup>
- Furniture, clothing, cosmetics, artwork, 1.4 W/ft<sup>2</sup>
- Fine jewelry, crystal & china, 2.5 W/ft<sup>2</sup>




Part VIII. Details of the Lighting Provisions  
**Space-by-Space Method**  
Section 9.6.2

**Example:**  
Calculate Total Lighting Power Allowance using the Space by Space Method:

Project is a Retail Building:

- ❑ 5000 sq. ft. of Sales Area including
- ❑ 1000 sq. ft. of jewelry counters
- ❑ 1000 sq. ft. of Active Storage Area
- ❑ 3 Enclosed Offices - 200 sq. ft. each
- ❑ 1 Conference Room - 400 sq. ft.
- ❑ 2 Rest Rooms - 150 sq. ft. each
- ❑ Corridors - 6' wide x 25' long



Part VIII. Details of the Lighting Provisions  
**Space-by-Space Method**  
Section 9.6.2

**Solution, Step #1:**  
Identify the Watts per Square Foot allowed for Each Space

Retail Building:

- ❑ Sales Area – 1.68 W/ft<sup>2</sup>
- ❑ Additional power allowances for jewelry cases lighting – 2.5 W/ft<sup>2</sup> of display
- ❑ Active Storage Area – 0.63 W/ft<sup>2</sup>
- ❑ Enclosed Offices - 1.11 W/ft<sup>2</sup>
- ❑ Conference Room - 1.23 W/ft<sup>2</sup>
- ❑ Rest Rooms – 0.98 W/ft<sup>2</sup>
- ❑ Corridors - 0.66 W/ft<sup>2</sup>




Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)


Part VIII. Details of the Lighting Provisions  
**Space-by-Space Method**  
Section 9.6.2

**Solution, Step #2:**  
Multiply W/ft<sup>2</sup> allowance by the area of each space. Add to calculate total power allowance.

Retail Building:

❑ Sales: 1.68 W/ft <sup>2</sup> x 5000 ft <sup>2</sup>	= 8,400 Watts
❑ Active Storage Area: 0.63 W/ft <sup>2</sup> x 1000 ft <sup>2</sup>	= 630 Watts
❑ Enclosed Offices: 1.11 W/ft <sup>2</sup> x (3) 200 ft <sup>2</sup>	= 666 Watts
❑ Conference Room: 1.23 W/ft <sup>2</sup> x 400 ft <sup>2</sup>	= 492 Watts
❑ Rest Rooms: 0.98 W/ft <sup>2</sup> x (2) 150 ft <sup>2</sup>	= 294 Watts
❑ Corridors: 0.66 W/ft <sup>2</sup> x 6' x 25'	= 99 Watts
<b>LIGHTING POWER ALLOWANCE</b>	<b>= 10,581 Watts</b>
Additional Power Allowance - Jewelry areas Only	
2.5 W/ft <sup>2</sup> x 1000 ft <sup>2</sup>	= 2,500 Watts
<b>TOTAL Int. Ltg. POWER ALLOWANCE</b>	<b>= 13,081 Watts *</b>
* 15,025 Watts when using 90.1-2007 (1,944 W saved.)	

15-min. Break



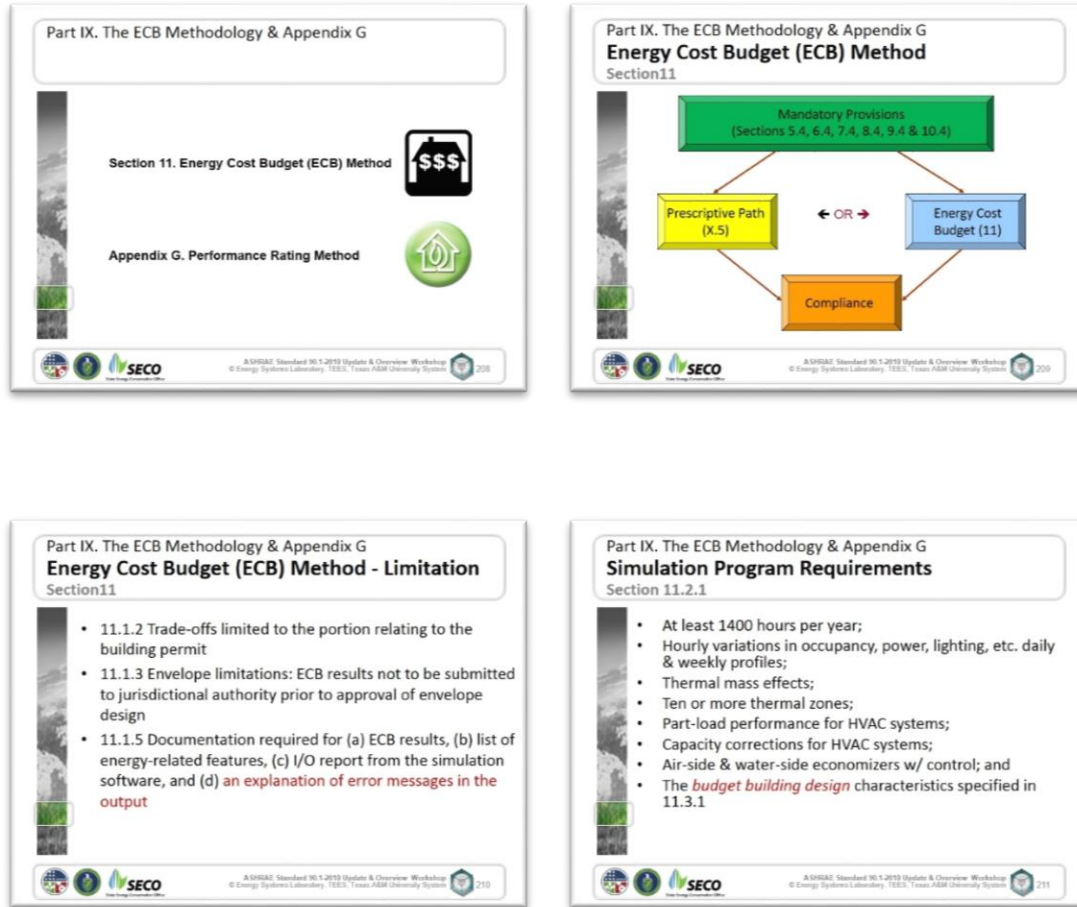
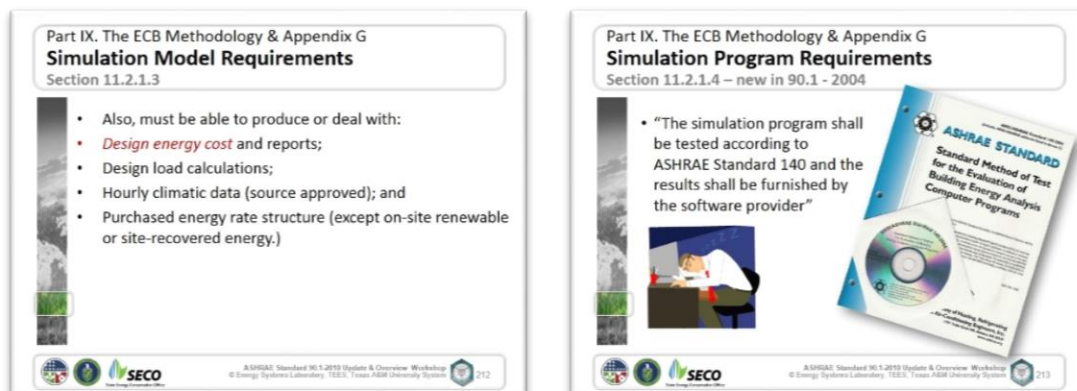


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





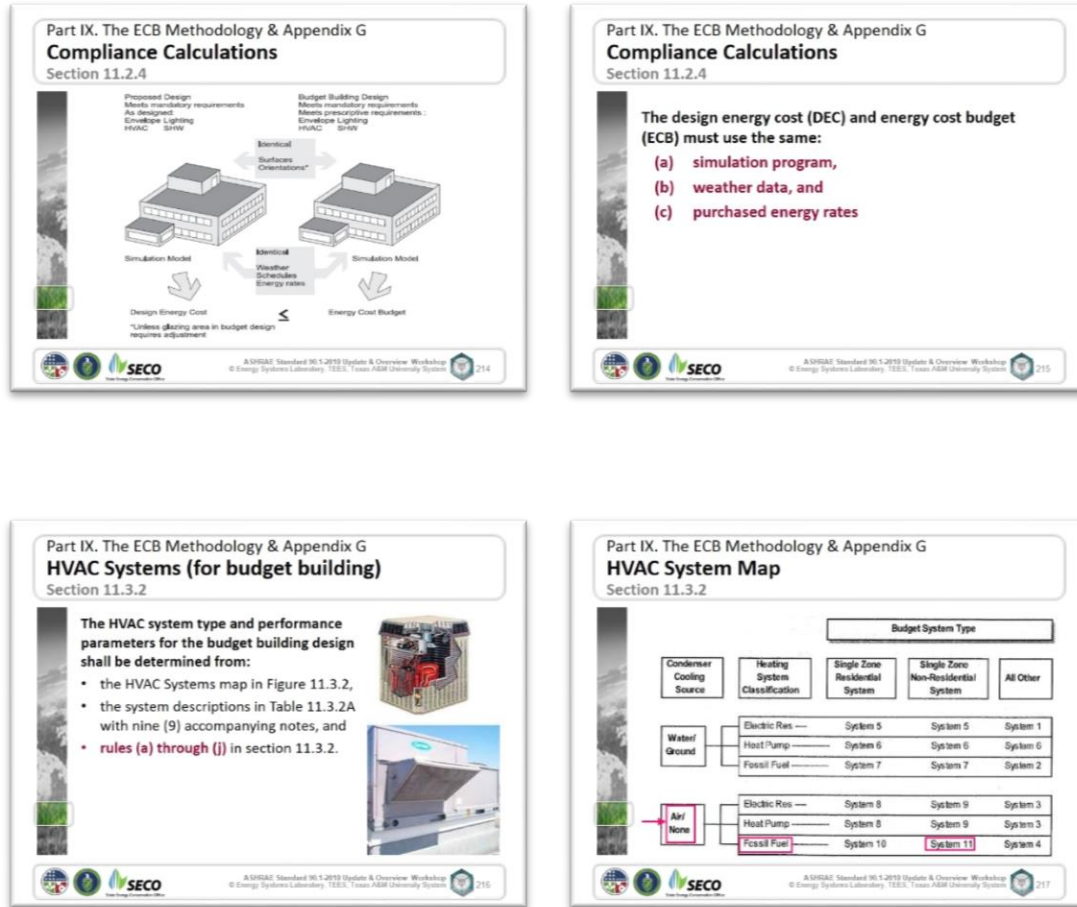
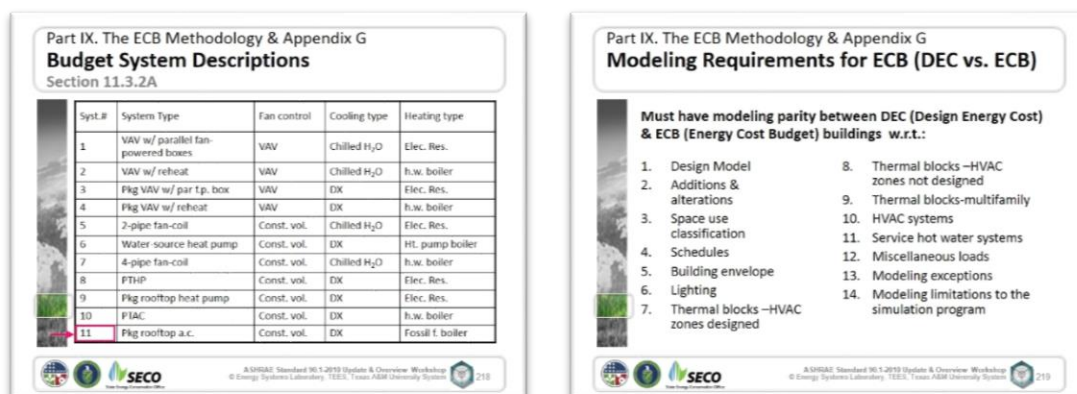


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



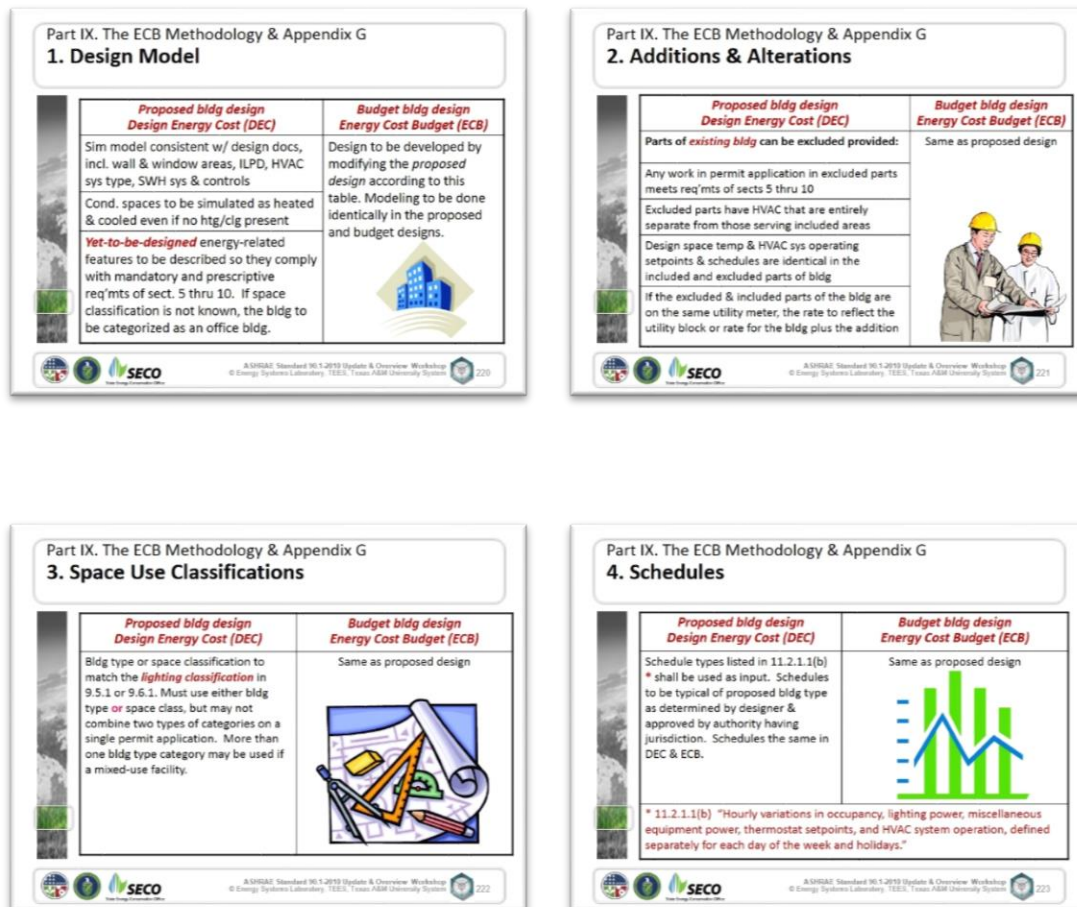


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

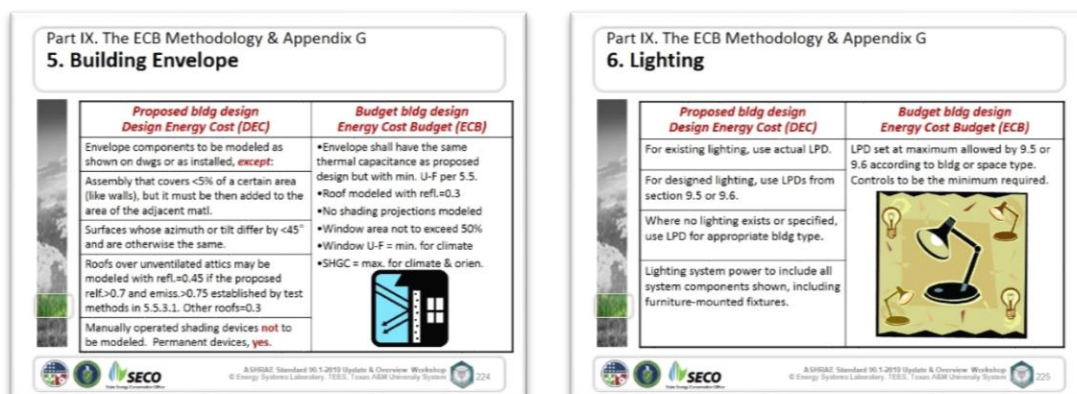
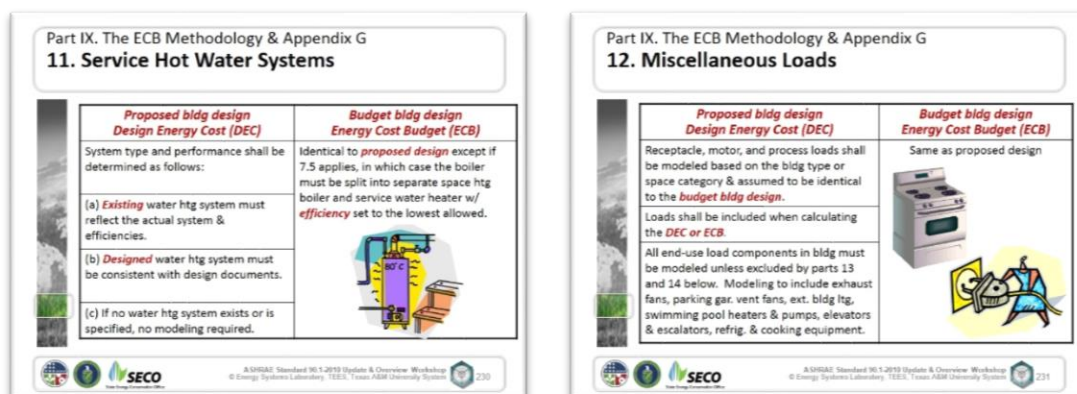







Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



Part IX. The ECB Methodology & Appendix G


### 13. Modeling Exceptions

Proposed bldg design Design Energy Cost (DEC)	Budget bldg design Energy Cost Budget (ECB)
Components and systems may be excluded from the simulation model if:	None
(a) component energy usage does not affect energy usage of systems and components that are being considered for trade-off, or	
(b) the exclusion conditions are met within the applicable prescriptive sections of 5.5, 6.5, 7.5, and either 9.5 or 9.6.	

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Part IX. The ECB Methodology & Appendix G


### 14. Modeling Limitations to the Simulation Program

Proposed bldg design Design Energy Cost (DEC)	Budget bldg design Energy Cost Budget (ECB)
If the simulation program cannot model a component or system in the design, one of the following methods shall be used, subject to approval of the <i>authority having jurisdiction</i> :	Same as proposed design.
(a) Ignore the component if energy impact on trade-offs are insignificant.	
(b) Model the component by substituting a thermodynamically similar component model.	
(c) Model the HVAC system components or systems using the <i>budget bldg design's</i> HVAC system in accordance with part 10 above.	
<b>Note:</b> Identical modeling method must be used for both the DEC and the ECB.	

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Part IX. The ECB Methodology & Appendix G

### Appendix G: Performance Rating Method

- Normative Appendix G 
- Provides specific rules for determining **degree of improvement** over 90.1
- Responding to demand by LEED designers
- Distinct from Energy Cost Budget compliance method (Section 11)

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Part IX. The ECB Methodology & Appendix G

### Normative Appendix G

Addendum "r" changed Appendix G (Performance Rating Method) from Informative to Normative.

❑ Special attention to:

- G1.4 – Documentation of calculated baseline and proposed building.
- G2.2.1 – Simulation program – same features as the ECB Method requirements, except must do 8760 hrs/year instead of only 1400.
- G2.5 – Exceptional Calculation Method – application, for approval of the method proposed for use

❑ And, for modeling requirements in Table G3.1:

- Table G3.1, Part 4 – Schedule differences permitted only for automatic controls, but not for manual.
- Table G3.1, Part 14 – Exterior Conditions (added)
  - ❖ To account for shading, ground temperatures, water main temperatures.

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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

Part IX. The ECB Methodology & Appendix G

### LEED Points from Appendix G

The Performance Rating Method is a way to enable LEED points; e.g., in USGB's LEED® - 2009 (v3)

- Minimum energy performance:
  - Comply with 90.1-2010 --
    - ✓ Mandatory provisions of 90.1-2010, and
    - ✓ Prescriptive requirements of 90.1-2010 or the ECB method, and
    - ✓ 10% improvement over 90.1-2010
  - Two prescriptive methods allowed (including AEDGs)
- Optimize energy performance:
  - 1 point for 12% savings
  - 3 points for 16% savings
  - Up to 19 points (out of 100)


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Part X. Beyond Codes

- ASHRAE Green Standard 189.1
- AEDGs
- Tax Incentives
- Energy Simulation Software

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**Part X. Beyond Codes**  
**Vision 2020**




**Purpose:**  
To provide tools by 2020 that enable the building community to produce market viable NZEBs by 2030.

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**Part X. Beyond Codes**  
**Sustainability Standards**

This can't be done alone. ASHRAE is partnering with other organizations that are recognized leaders in setting national energy efficiency goals: AIA, US-DOE, USGBC, and the IESNA.




ASHRAE's Sustainability Standards:

- 90.1-2010 – Prescriptive & Performance
- 189.1 – High Performance and Green Buildings
- 189.2 – High Performance Green Healthcare Facilities
- 191 – Water Conservation Standard

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**Part X. Beyond Codes**  
**ASHRAE GreenGuide, 3rd Ed.**  
A must for HVAC system designers, green builders, and landscape architects



In 488 pages, includes numerous "Green Tips," specific measures for improving sustainability:

- Hybrid Ventilation
- Ground-Source Heat Pumps
- Direct-Contact Water Heaters
- Sustainable energy master planning
- Teaming strategies
- Carbon emissions effect
- Greening existing buildings
- Green-building rating systems
- Building energy modeling and follow-up
- Measurement and verification
- Compliance strategies for key ASHRAE standards
- Water efficiency
- Chilled-water plant and boiler plant design

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**Part X. Beyond Codes**  
**ASHRAE GreenGuide**

**There's an App for that:**

The third edition of the *ASHRAE GreenGuide: The Design, Construction and Operation of Sustainable Buildings*, is available in iPad eBook format. The GreenGuide eBook includes embedded links to sections of the book, graphics and relevant Web pages. The GreenGuide eBook is available as a download in Apple's iBooks store for \$39.99 and requires the free iBooks app.

Free iBooks App:  
<http://www.apple.com/ipad/built-in-apps/ibooks.html>


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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

**Part X. Beyond Codes**  
**ASHRAE/USGBC/IESNA Standard 189.1**

**Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings**

- Purpose: To provide minimum requirements for the design of high-performance, green buildings to:
  - (a) Balance environmental responsibility, resource efficiency, occupant comfort and well being, and community sensitivity, and
  - (b) Support the goal of the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
- Partners – USGBC, IESNA




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**Part X. Beyond Codes**  
**ASHRAE/USGBC/IESNA Standard 189.1**

Standard 189.1 is meant to complement green building rating programs and not compete with them.

**Standard 189-2009 Contents**

1. Purpose
2. Scope
3. Definitions, Abbreviations
4. Administration & Enforcement
5. Site Sustainability
6. Water Use Efficiency
7. **Energy Efficiency (supersedes 90.1)**
8. IEQ
9. Impact on Environment
10. Construction & Operation Plans



ASHRAE Standard 90.1-2010 Update & Overview Workshop  
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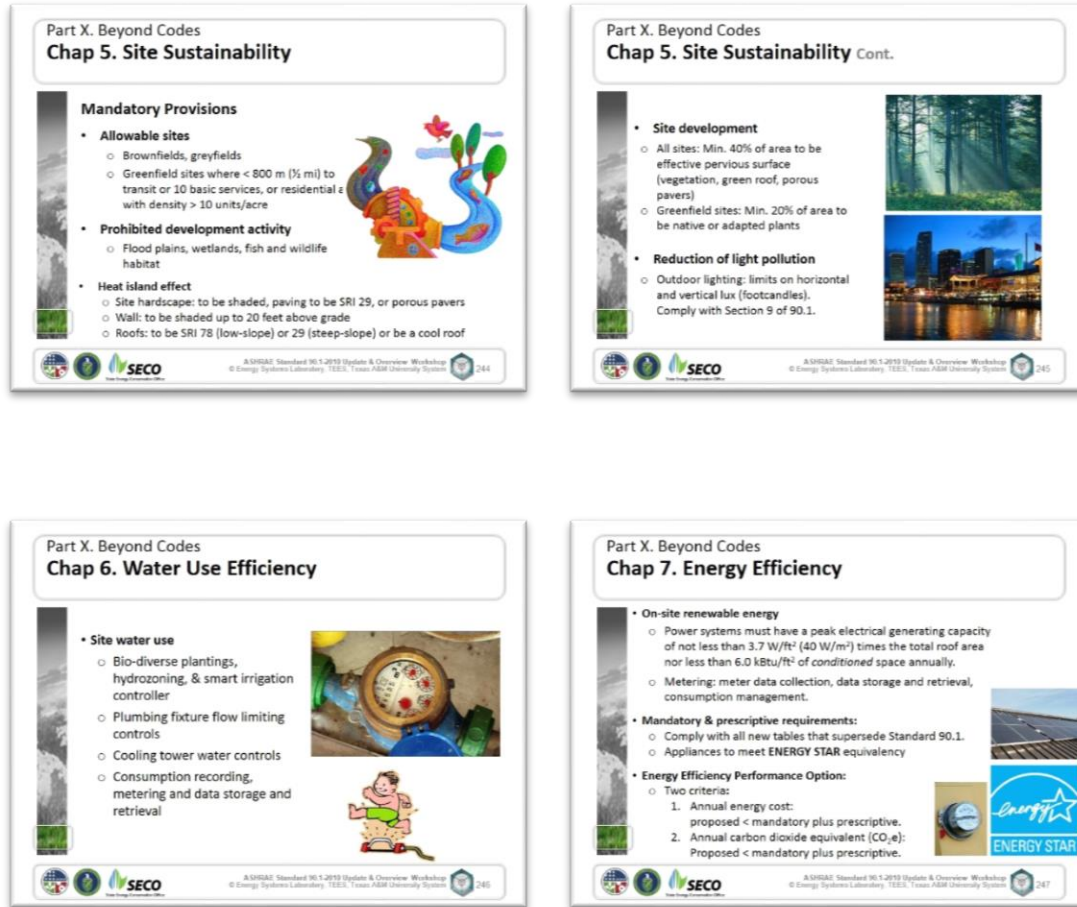


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)





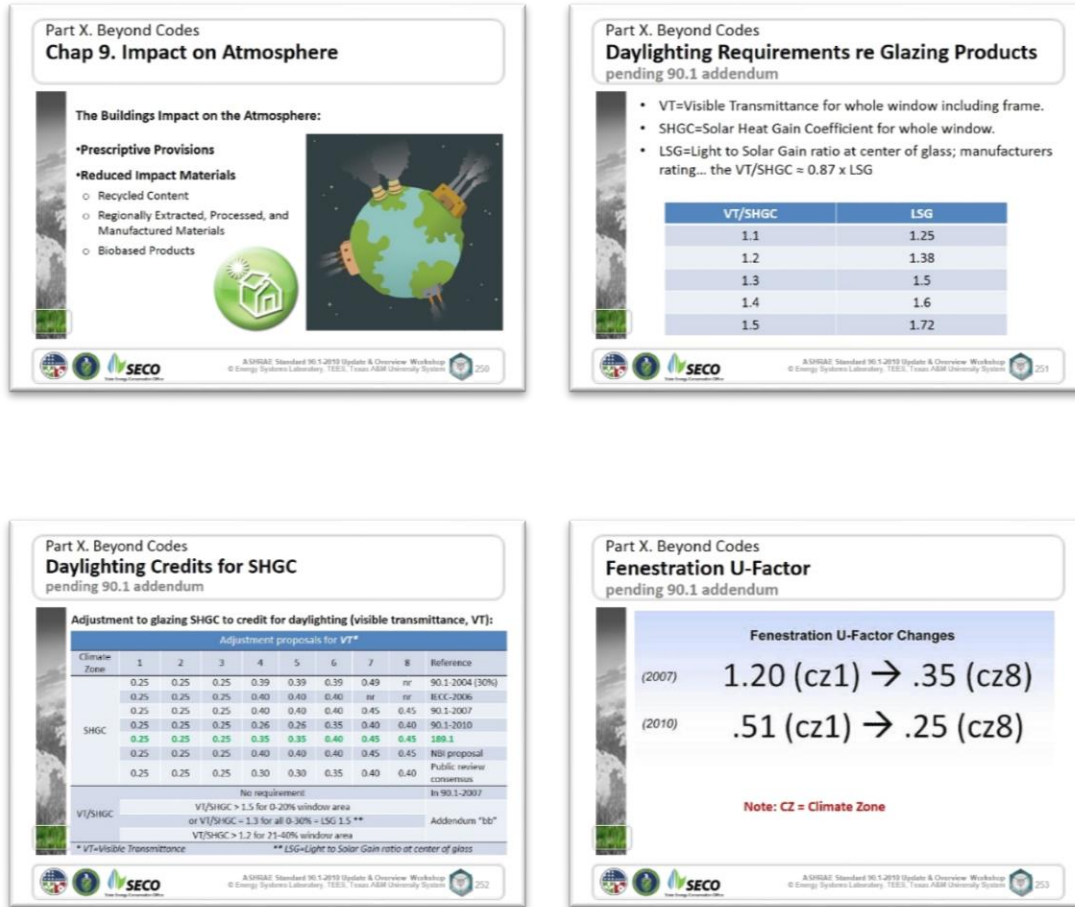
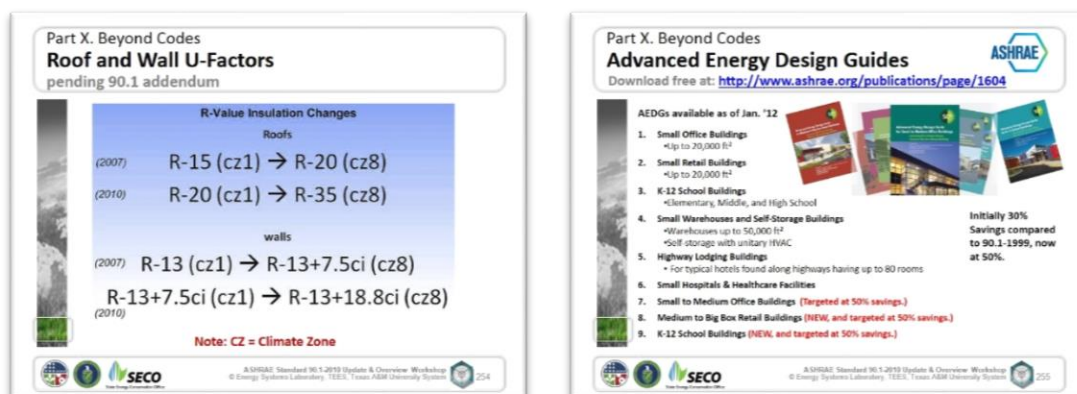


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



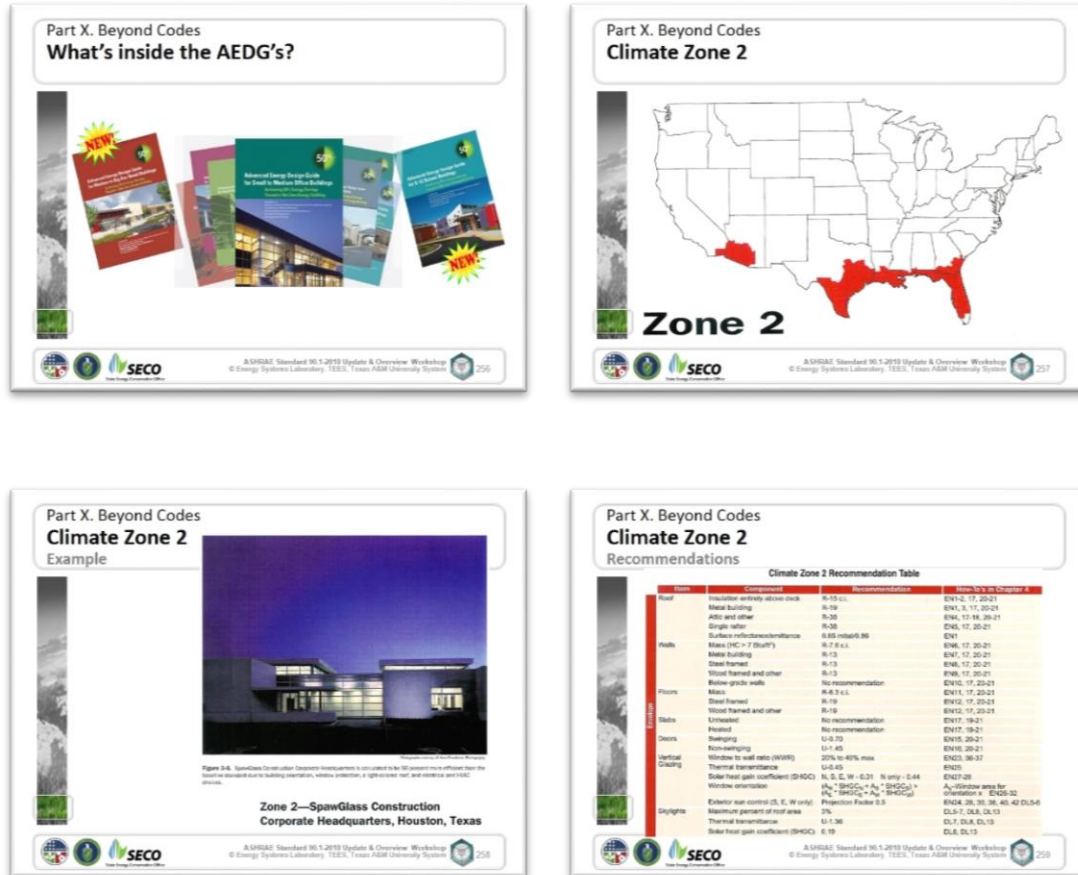


Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)



Part X. Beyond Codes  
**How-To's in Chapter 4**

**EN27 Glazing (Climate Zones: ☀ ☁ ☂ ☃ ☄ ★ ☆ ☇ ☈ ☉)**

Figure 4-19. (EN27) Exterior sun control.

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Part X. Beyond Codes  
**Tax Incentives**

- **Energy-efficient Commercial building deduction.**  
This provision allows a tax deduction for energy-efficient commercial buildings that reduce annual energy and power consumption by 50% compared to the ASHRAE 90.1-2001 standard. The deduction would equal the cost of energy-efficient property installed during construction, with a maximum deduction of \$1.80 per square foot of the building. Additionally, a partial deduction of 60 cents per square foot would be provided for building subsystems.
- **Consumer tax credits:** Up through Dec 31, 2016, 30% of the cost (up to \$1500 for efficient appliances) and with no upper for renewable energy systems (geothermal, solar, wind turbines) -- for existing homes & new construction
  - Web site:
  - [http://www.energystar.gov/index.cfm?c=tax\\_credits.tx\\_index](http://www.energystar.gov/index.cfm?c=tax_credits.tx_index)

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Part X. Beyond Codes  
**Qualified Software for Federal Tax Deductions**  
Qualified Computer Software for Calculating Energy Savings for Purposes of the Energy-Efficient Commercial Building Tax Deduction under Internal Revenue Code §179D.

Source: [http://www1.eere.energy.gov/buildings/qualified\\_software.html](http://www1.eere.energy.gov/buildings/qualified_software.html) [10/3/11]

Software name, latest version submitted, and date DOE received latest full documentation

Software name	Latest version submitted	Date DOE received latest full documentation
DesignBuilder	3.6.0.097	3/12/12
EnergyPlus	7.0	12/19/11
Green Building Studio	3.4	10/16/08
DOE 2.2	476	9/30/06
DOE 2.1E	119	7/2/07
DOE 2.1E-UIH	130	11/5/07
eQuest	3.6.3b	9/9/09
EnergyGauge	3.22	1/14/10
Energy Pro	5.1	1/20/10
EnerSim	9.02	12/16/09
Hourly Analysis Program (HAP)	4.41	4/10/09
IES Virtual Environment	6.3	3/30/11
Owens Corning (OC-CEC)	1.1	8/24/07
Trace 700	6.2.6	9/9/10
VisualDOE	4.1 build 0002	9/11/06

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Part X. Beyond Codes  
**ASHRAE Compliance Forms**  
Simplified HVAC sample - Top and bottom segments

**HVAC Simplified Approach Option** Part I

Project Name: \_\_\_\_\_ Date: \_\_\_\_\_  
 Project Address: \_\_\_\_\_ City: \_\_\_\_\_  
 HVAC System Designer of Record: \_\_\_\_\_ Telephone: \_\_\_\_\_  
 Contact Person: \_\_\_\_\_ Telephone: \_\_\_\_\_

System Type	Mfg. & Model No.	Equipment Type	Heating			Cooling			EER, Min. Efficiency
			Rated Capacity	Rated Efficiency	Minimum Efficiency	Rated Capacity	Rated Efficiency	Minimum Efficiency	

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Part X. Beyond Codes  
**ASHRAE HVAC Compliance Forms**  
HVAC sample - Segment mandatory portion

**HVAC Mandatory Provisions** Part II, Page 1

Project Name: \_\_\_\_\_ Date: \_\_\_\_\_  
 Project Address: \_\_\_\_\_ City: \_\_\_\_\_  
 HVAC System Designer of Record: \_\_\_\_\_ Telephone: \_\_\_\_\_  
 Contact Person: \_\_\_\_\_ Telephone: \_\_\_\_\_  
 City: \_\_\_\_\_ Climate Data: \_\_\_\_\_  
 1% Summer DB Temp: \_\_\_\_\_ 1% Summer WB Temp: \_\_\_\_\_ 99.9% Winter Temp: \_\_\_\_\_

System Type	Equipment Type (Tables 6.5.1A through G)	Size Category (Tables 6.5.1A through G)	Unit of Efficiency (Tables 6.5.1A through G)	Rated	2	Required

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Part X. Beyond Codes  
**ASHRAE Envelope Compliance**  
Envelope sample - Top segment of form

**Building Envelope Compliance Documentation** Part II, Page 1

Project Name: \_\_\_\_\_ Date: \_\_\_\_\_  
 Project Address: \_\_\_\_\_ City: \_\_\_\_\_  
 HVAC System Designer of Record: \_\_\_\_\_ Telephone: \_\_\_\_\_  
 Contact Person: \_\_\_\_\_ Telephone: \_\_\_\_\_

Description/Name	Class (Pick one)						U-factor	Area (ft²)	Total U-factor Area (ft²)	Surface Area (ft²) (optional)
	Roof	Wall	Floor	Slab	Door	Window				

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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

[illegible]

<h2 style="margin: 0;">Part X. Beyond Codes</h2> <h1 style="margin: 0;">ASHRAE Lighting Compliance</h1> <p style="margin: 0;">Lighting sample - Top segment of page 3</p>										
<b>Lighting Compliance Documentation</b>										
<b>Page 3</b>										
Project Name:	Telephone:									
Contact Person:										
A-Additional Interior Connected Lighting Power										
ID	Luminaire Description (including number of lamps per fixture, watts per lamp, type of ballast, type of fixture)	Type						Number of Luminaires	Watts/Luminaire	Total Watts
		Incandescent	Fluorescent	HID	Vapor Lamps	LED	Other			
								Total		

## Workshop Wrap-up

- Q & A discussion (if any.)
- Additional sources of information.
- Don't forget to submit your workshop evaluation sheets and sign up for CEU credits.

IAAE Standard 90.1-2010 Update & Overview Workshop

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## Digging Deeper Options

**ASHRAE Standards, Guidelines, Online Courses & Users Manuals at the ASHRAE Bookstore**  
(Provides much of the background):

- <http://www.ashrae.org/technology/page/548>
- <http://www.techstreet.com/ashraegate.html>
- <https://www.ashrae-elearning.org/>

**Formal Interpretations, but**  
Formal written interpretations take time.

**Informal Interpretations,**  
Quick, informal answers to questions.

Or, Contact ASHRAE Manager of Standards  
by phone at (404) 636-8400

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## Where to Get More Information

- [www.ashrae.org](http://www.ashrae.org) and local ASHRAE chapters
- [www.seco.cpa.state.tx.us/](http://www.seco.cpa.state.tx.us/)
- [www.enrcodes.gov](http://www.enrcodes.gov)
- [www.nfrc.org](http://www.nfrc.org)
- [www.ansi.org](http://www.ansi.org)
- [www.ahrinet.org](http://www.ahrinet.org)
- [www.icccampus.org](http://www.icccampus.org)
- <http://energysystems.tamu.edu>






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## Copies of the 90.1 Standards?




Standards 90.1-1999, 2001, 2004, 2007, 2010 and matching users manuals are available from ASHRAE.

Preview entire 90.1-2010 document or the 189.1-2009 document free at:  
<http://www.ashrae.org/technology/page/548>

(404) 636-8400





ASHRAE Standard 90.1-2010 Update & Overview Workshop

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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

### ASHRAE Certification Program

- ASHRAE has recognized the importance of having high standards for building professionals as well as having standards for the buildings. Accordingly, ASHRAE has begun to certify the professional by offering certifications in a number of building performance areas:
- Building Energy Modeling Professional
- Commissioning Process Management Professional
- Healthcare Facility Design Professional
- High-performance Building Design Professional
- Operations & Performance Management Professional
- To learn more, visit: <http://www.ashrae.org/certification>

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### Additional Information

**Technical Contact:**  
Larry Degelman, P.E.  
[ldegelman@suddenlink.net](mailto:ldegelman@suddenlink.net)  
College Station, TX

**Additional information on code training and adoptions in specific municipalities:**

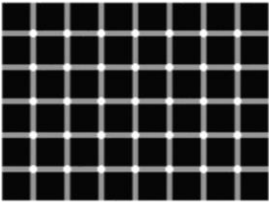
**Felix Lopez, P.E.**  
[felix.lopez@cpa.state.tx.us](mailto:felix.lopez@cpa.state.tx.us)  
Comptroller of Public Accounts, SECO

**Bahman Yazdani, P.E.**  
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**Shirley Ellis**  
[shirleyellis@tamu.edu](mailto:shirleyellis@tamu.edu)  
Energy Code Specialist  
Energy Systems Laboratory, TEES

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### Mandatory Exam



Count the black dots! :o)

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### Discussion / Adjournment



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Figure 24: ASHRAE 90.1 Standard Update Workshop (continued)

### 1.10 Evaluation of Additional Technologies for Reducing Energy Use in Existing Buildings

The Laboratory provided technical assistance to the TCEQ, the PUCT, SECO and ERCOT, as well as Stakeholders participating in the Energy Code and Renewables programs.

- In 2008, the Laboratory continued to work with the TCEQ to develop an integrated NOx emissions reductions calculation that provided the TCEQ with a creditable NOx emissions reductions from energy efficiency and renewable energy (EE/RE) programs reported to the TCEQ in 2008 by the Laboratory, PUCT, SECO, and ERCOT (i.e., wind).
- At the request of the TCEQ, the Laboratory has continued the development of procedures for quantifying NOx emissions reductions from wind turbines that includes weather normalization and the quantification of NOx emissions reductions from the new Federal regulations for SEER 13 air conditioners.

### 1.11 Planned Focus for 2013

In FY 2013, the Energy Systems Laboratory will continue in its cooperative efforts with the TCEQ, PUCT, SECO, US EPA and others to evaluate the energy savings resulted from the EE/RE measures and programs of the TERP and their impact on air quality, and continue with the energy code state-wide implementation assistance under the Texas Building Energy Performance Standards program of the TERP. The Laboratory team will:

- Assist the TCEQ to obtain SIP credits from energy efficiency and renewable energy using the Laboratory's Emissions Reduction Calculator technology;
- Verify, document and report energy efficiency and renewable energy savings in all TERP EE/RE programs for the SIP in each non-attainment and affected county using the TCEQ/US EPA approved technology;
- Assist the PUCT with determining emissions reductions credits from energy efficiency programs funded by SB 7 and SB 5;
- Assist political subdivisions and Councils of Governments with calculating emissions reductions from local code changes and voluntary EE/RE programs for SIP inclusion;
- Continue to refine the cost-effective techniques to implement 15% above code (2009 IECC) energy efficiency in low-priced and moderately-priced residential housing;
- Continue to refine the cost-effective methods and techniques to implement 15% above code energy efficiency in low-priced and moderately-priced commercial buildings;
- Continue to develop creditable procedures for calculating NOx emissions reductions from green renewable technologies, including wind power, solar energy and geothermal energy systems;
- Continue development of well-documented, integrated NOx emissions reductions methodologies for calculating and reporting NOx reductions, including a unified database framework for required reporting to TCEQ of potentially creditable measures from the ESL, PUCT, and SECO SB 5 initiatives;
- Upon request, provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC), or the International Energy Conservation Code (IECC), are equivalent to, or better than, the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC. This will consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- Develop a standardized report format to be used by providers of home energy ratings, including different report formats for rating newly constructed residences from those for existing residences.
- Continue to cooperate with an industry organization or trade association to: develop guidelines for home energy ratings; provide training for individuals performing home energy ratings and providers of home energy ratings; and provide a registry of completed ratings for newly constructed residences and residential improvement projects for the purpose of computing the energy savings and emissions reductions benefits of the home energy ratings program.
- Include all benefits attained from this program in an annual report to the commission.
- Enhance IC3 to support multifamily residences, and add other features to enhance adoption.

- Engage production builders and municipalities in overcoming obstacles to their using IC3 for their new home construction.
- Seek funding to enhance TCV IC3. Assist SECO in refining the form on which political subdivisions need to report annually their electric consumption.
- Assist SECO in developing a new standardized reporting form for all municipally owned utilities and electric cooperatives, which had retail sales of more than 500,000 MWh in 2005, to report the combined effects of their energy efficiency activities from the previous calendar year.
- Send a representative to SECO's new advisory committee for selecting high-performance building design evaluation systems.

The Laboratory has and will continue to provide leading-edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP.

If any questions arise, please contact us by phone at 979-845-1280, or by email at [terpinfo@tees.tamus.edu](mailto:terpinfo@tees.tamus.edu).

## 2. Introduction

### 2.1 Background

In 2001, the Texas Legislature adopted the Texas Emissions Reduction Plan, identifying thirty-eight counties in Texas where a focus on air quality improvements was deemed critical to public health and economic growth. These areas are shown on the map in [Figure 25](#) as non-attainment and near nonattainment. In 2008, the twenty counties designated as nonattainment counties include: Brazoria, Chambers, Collin, Dallas, Denton, Ellis, Fort Bend, Hardin, Harris, Jefferson, Galveston, Johnson, Kaufman, Liberty, Montgomery, Orange, Parker, Rockwall, Tarrant, and Waller Counties. The fourteen counties designated as Ozone Early Action Compact counties include: Bastrop, Bexar, Caldwell, Comal, Gregg, Guadalupe, Harrison, Hays, Rusk, Smith, Travis, Upshur, Williamson, and Wilson County.

These counties represent several geographic areas of the state, which have been assigned to different climate zones by the 2001 IECC<sup>8</sup> as shown in Figure 26, based primarily on Heating Degree Days (HDD). These include climate zone 5 or 6 (i.e., 2,000 to 2,999 HDD<sub>65</sub>) for the Dallas-Ft. Worth and El Paso areas, and climate zones 3 and 4 (i.e., 1,000 to 1,999 HDD<sub>65</sub>) for the Houston-Galveston-Beaumont-Port Arthur-Brazoria areas. Also shown in Figure 26 are the locations of the various weather data sources, including the Typical Meteorological Year (TMY2) (NREL 1995) stations, the Weather Year for Energy Calculations (WYEC2) (Stoffel 1995) weather stations, the National Weather Service weather stations, (NWS) (NOAA 1993) weather stations, the ASHRAE 90.1 1989 weather locations<sup>9</sup>, the ASHRAE 90.1 1999 weather locations, the solar stations measured by the National Renewable Energy Laboratory (NREL)<sup>10</sup>, the solar stations measured by the TCEQ<sup>11</sup>, and F-CHART and PV F-CHART weather locations<sup>12</sup>.

<sup>8</sup> The "2000 IECC" notation is used to signify the 2000 International Residential Code (IRC), which includes the International Energy Conservation Code (IECC) as modified by the 2001 Supplement (IECC 2001), published by the ICC in March of 2001, as required by Senate Bill 5.

<sup>9</sup> The ASHRAE 90.1-1989 and 90.1-1999 weather stations are used in the emissions calculator for determining the building characteristics.

<sup>10</sup> The NREL stations were the primary source of the 1999 global horizontal, direct normal and diffuse solar radiation used to determine the 1999 peak-day and annual emissions for the DOE-2 simulations for code-compliant housing and commercial buildings.

<sup>11</sup> The TCEQ stations were used as the secondary source for global horizontal solar radiation when the NREL sites were missing data or no NREL site was nearby.

<sup>12</sup> The F-Chart and PV F-Chart weather locations are used to determine the solar thermal or electricity produced by the systems specified by the use in the emissions calculation. The monthly energy or electricity production from F-Chart or PV F-Chart is then weather-normalized using

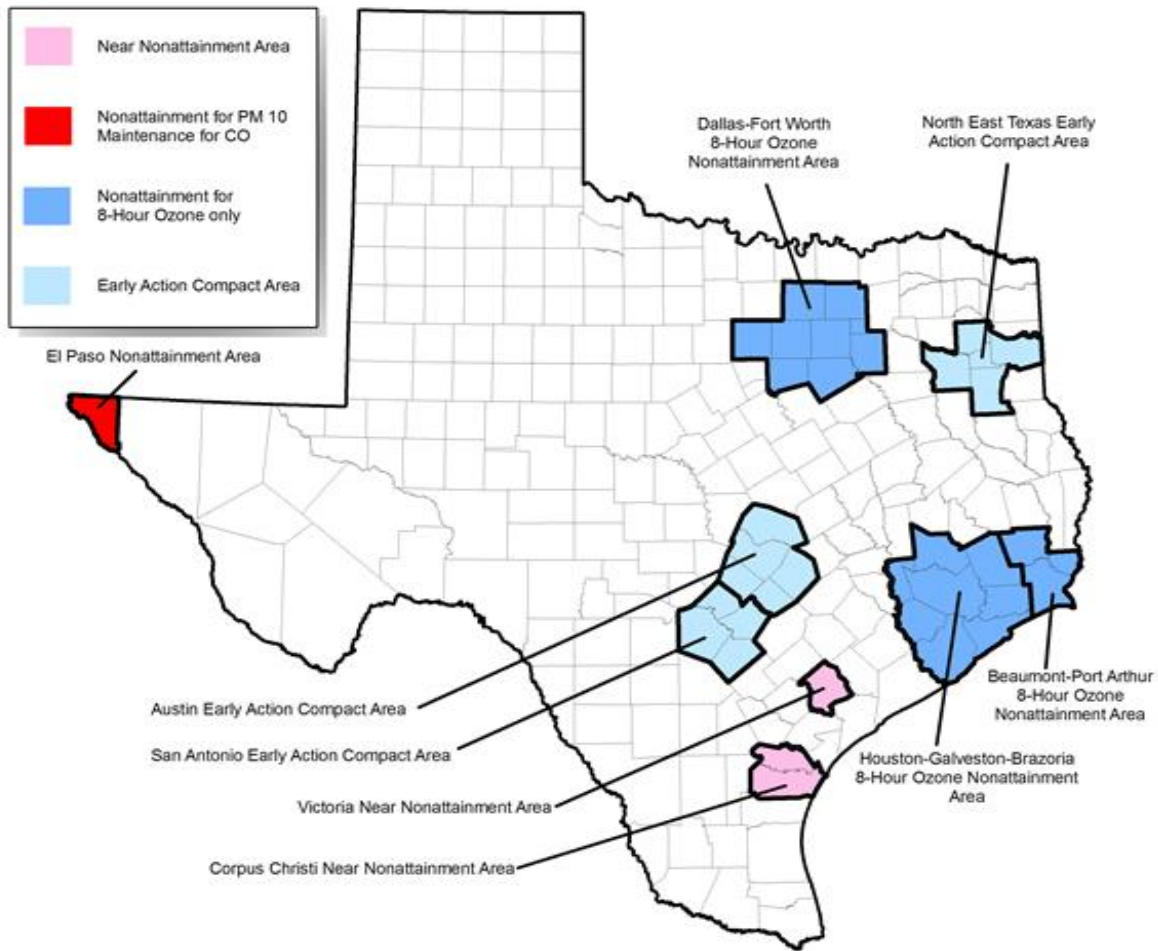


Figure 25: US EPA Nonattainment and Near Nonattainment

## 2.2 Energy Systems Laboratory's Responsibilities in the TERP

In 2001, Texas Senate Bill 5 outlined the following responsibilities for the Energy Systems Laboratory (ESL) within the TERP:

- Sec. 386.205. Evaluation of State Energy Efficiency Programs.
- Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards.
- Sec. 388.004. Enforcement of Energy Standards Outside of Municipality.
- Sec. 388.007. Distribution of Information and Technical Assistance.
- Sec. 388.008. Development of Home Energy Ratings.

In 2003 these responsibilities were modified by the following:

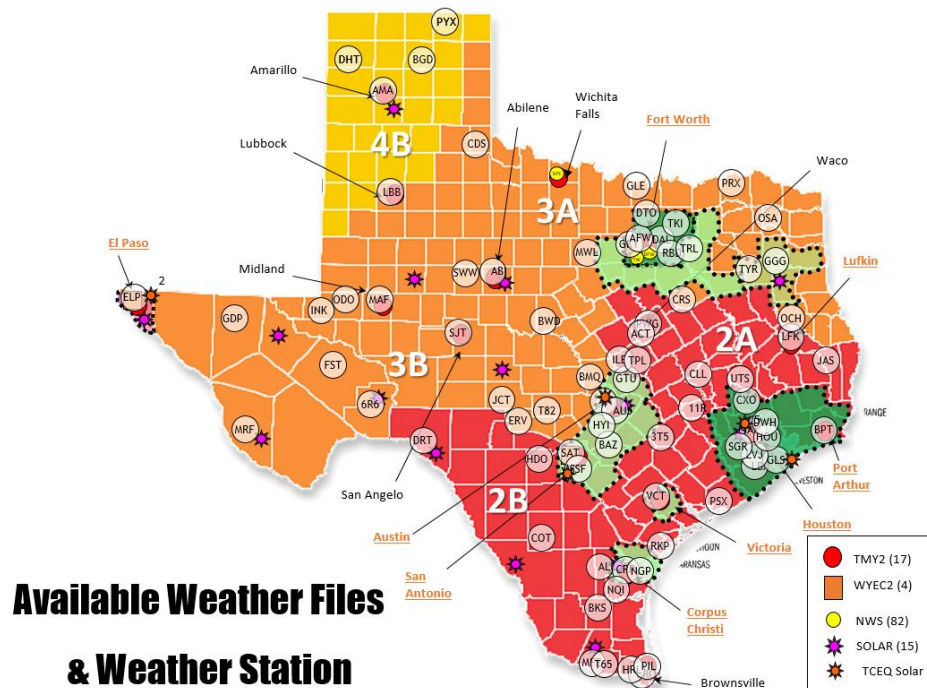
- House Bill 1365, including modifications to:
  - Sec. 388.004. Enforcement of Energy Standards Outside of Municipality
  - Sec. 388.009. Energy-Efficient Building Program
- House Bill 3235 which includes modifications to

---

ASHRAE's Inverse Model Toolkit to develop coefficients that are then used to determine the 1999 annual and peak day energy or electricity production for emissions calculations.



- Sec. 388.009. Certification of Municipal Building Inspectors.



List of Available Weather Files and Weather Stations of Texas			
<b>Texas Weather Stations (#10AA)</b>			
1	Abilene Regional Airport (ABI)	51	Lubbock International Airport (LBB)
2	Albino International Airport (ALB)	52	Lufkin Angelika City Airport (LKF)
3	Amarillo International Airport (AMA)	53	Marfa: MARFA MUNICIPAL AIRPORT (MRF)
4	Arlington Municipal Airport (ARL)	54	McKinney Municipal Airport (MKY)
5	Austin-Bergstrom International Airport (AUS)	55	Midland International Airport (MAF)
6	Austin-Camp Mabey (ACT)	56	Mineral Wells Airport (MWL)
7	Beggs Regional Airport (BEG)	57	Mount Pleasant: MOUNT PLEASANT REGIONAL AIRPORT (OCH)
8	Brownsville International Airport (BRO)	58	Nacogdoches: A. L. BANGHAM JR. REGIONAL AIRPORT (OCH)
9	Brownsville-S. Padre Island International Airport (BRO)	59	New Braunfels Municipal Airport (BAZ)
10	Brownsville: BROWNWOOD REGIONAL AIRPORT (BRO)	60	Oberlin: OBERLIN FIELD (OOB)
11	Brownsville: BROWNWOOD REGIONAL AIRPORT (BRO)	61	Odessa: ODessa FIELD (ODO)
12	Brownsville: BROWNWOOD REGIONAL AIRPORT (BRO)	62	Paducah: PADUCAH AIRPORT (PGC)
13	Chandler Municipal Airport (CHD)	63	Paris: COX FIELD AIRPORT (PRX)
14	College Station (CLG)	64	Perryton: PERRYTON OCHILTREE COUNTY AIRPORT (PXX)
15	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	65	Pine Springs: GRADSHIRE MOBILE (GDP)
16	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	66	Port Aransas: PORT ARANSAS AIRPORT (BPT)
17	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	67	Port Isabel: CAMERON COUNTY AIRPORT (PIL)
18	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	68	Rodriguez: RODRIGUEZ COUNTY AIRPORT (RKP)
19	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	69	San Antonio: SAN ANTONIO INTERNATIONAL AIRPORT (SAT)
20	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	70	San Antonio: SAN ANTONIO INTERNATIONAL AIRPORT (SAT)
21	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	71	San Antonio: SAN ANTONIO INTERNATIONAL AIRPORT (SAT)
22	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	72	San Marcos: SAN MARCOS MUNICIPAL AIRPORT (HYI)
23	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	73	Sweetwater: AVENGER FIELD AIRPORT (SWH)
24	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	74	Temple: DRAUGHON-MILLER CENTRAL TEXAS REGIONAL AIRPT (TPL)
25	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	75	Terrell: TERRELL AIRPORT (TRL)
26	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	76	Tyler: TYLER FIELD (TYR)
27	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	77	Victoria: VICTORIA AIRPORT (VCT)
28	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	78	Waco: MC GREGOR EXECUTIVE AIRPORT (WUG)
29	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	79	Waco: WACO REGIONAL AIRPORT (ACT)
30	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	80	Weslaco: MID VALLEY AIRPORT (TOS)
31	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	81	Wichita Falls: WICHITA FALLS AIRPORT (SFS)
32	Corpus Christi: CORPUS CHRISTI NAS/TRAUX FIELD AIRPT (NGP)	82	Wichita Falls: WICHITA FALLS AIRPORT (SFS)
<b>Texas WYEC2 Weather Files</b>			
1	Abilene	1	Abilene
2	Amarillo	2	Amarillo
3	Austin	3	Austin
4	Brownsville	4	Brownsville
5	Corpus Christi	5	Corpus Christi
6	El Paso	6	El Paso
7	Fort Worth	7	Fort Worth
8	Houston	8	Houston
9	Lubbock	9	Lubbock
10	Lufkin	10	Lufkin
11	Midland	11	Midland
12	Port Arthur	12	Port Arthur
13	San Antonio	13	San Antonio
14	San Marcos	14	San Marcos
15	Victoria	15	Victoria
16	Waco	16	Waco
17	Wichita Falls	17	Wichita Falls
<b>Texas TMY2 Weather Files</b>			
1	Abilene	1	Abilene
2	Amarillo	2	Amarillo
3	Austin	3	Austin
4	Brownsville	4	Brownsville
5	Corpus Christi	5	Corpus Christi
6	El Paso	6	El Paso
7	Fort Worth	7	Fort Worth
8	Houston	8	Houston
9	Lubbock	9	Lubbock
10	Lufkin	10	Lufkin
11	Midland	11	Midland
12	Port Arthur	12	Port Arthur
13	San Antonio	13	San Antonio
14	San Marcos	14	San Marcos
15	Victoria	15	Victoria
16	Waco	16	Waco
17	Wichita Falls	17	Wichita Falls
<b>Texas NREL Solar Stations</b>			
1	Abilene	1	Abilene
2	Amarillo	2	Amarillo
3	Austin	3	Austin
4	Brownsville	4	Brownsville
5	Corpus Christi	5	Corpus Christi
6	El Paso	6	El Paso
7	Fort Worth	7	Fort Worth
8	Houston	8	Houston
9	Lubbock	9	Lubbock
10	Lufkin	10	Lufkin
11	Midland	11	Midland
12	Port Arthur	12	Port Arthur
13	San Antonio	13	San Antonio
14	San Marcos	14	San Marcos
15	Victoria	15	Victoria
16	Waco	16	Waco
17	Wichita Falls	17	Wichita Falls
<b>TCEQ Solar Stations</b>			
1	Abilene	1	Abilene
2	Amarillo	2	Amarillo
3	Austin	3	Austin
4	Brownsville	4	Brownsville
5	Corpus Christi	5	Corpus Christi
6	El Paso	6	El Paso
7	Fort Worth	7	Fort Worth
8	Houston	8	Houston
9	Lubbock	9	Lubbock
10	Lufkin	10	Lufkin
11	Midland	11	Midland
12	Port Arthur	12	Port Arthur
13	San Antonio	13	San Antonio
14	San Marcos	14	San Marcos
15	Victoria	15	Victoria
16	Waco	16	Waco
17	Wichita Falls	17	Wichita Falls
<b>FCHART and PV FCHART (New Weather File)</b>			
1	Abilene	1	Abilene
2	Amarillo	2	Amarillo
3	Austin	3	Austin
4	Brownsville	4	Brownsville
5	Corpus Christi	5	Corpus Christi
6	El Paso	6	El Paso
7	Fort Worth	7	Fort Worth
8	Houston	8	Houston
9	Lubbock	9	Lubbock
10	Lufkin	10	Lufkin
11	Midland	11	Midland
12	Port Arthur	12	Port Arthur
13	San Antonio	13	San Antonio
14	San Marcos	14	San Marcos
15	Victoria	15	Victoria
16	Waco	16	Waco
17	Wichita Falls	17	Wichita Falls

Figure 26: Available NWS, TMY2 and WYEC2 weather files compared to IECC/IRC weather zones for Texas

In 2005 these same responsibilities were further updated:

- with Senate Bill 20, House Bill 2481, and 2129.

These responsibilities were further updated in 2007:

- with Senate Bill 12 and House Bill 3693.

These responsibilities were further updated in 2009:

- with House Bill 1796.

These responsibilities were further updated in 2011:

- with Senate Bills 898 and 924, and House Bill 51.

These responsibilities were not updated in 2012.

In the following sections each of these tasks is further described.

#### 2.2.1 (SB 5) Section 386.205. Evaluation of State Energy Efficiency Programs (w/PUCT)

The Laboratory is instructed to assist the Public Utility Commission of Texas (PUCT) and provide an annual report that quantifies by county the reductions of energy demand, peak loads, and associated emissions of air contaminants achieved from the programs implemented under this subchapter and from those implemented under Section 39.905, Utilities Code (i.e., Senate Bill 7).

#### 2.2.2 (SB 5) Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards.

TERP adopts the energy efficiency chapter of the 2001 International Residential Code (2001 IRC) as an energy code for single-family residential construction, and the 2001 International Energy Conservation Code (2001 IECC) for all other residential, commercial and industrial construction in the state. It requires that municipalities establish procedures for administration and enforcement, and ensure that code-certified inspectors perform inspections.

TERP provides that local amendments, in non-attainment areas and affected counties, may not result in less stringent energy efficiency requirements. The Laboratory is to review local amendments, if requested, and submit an annual report of savings impacts to the TCEQ. The Laboratory is also authorized to collect fees for certain of its tasks in Sections 388.004, 388.007 and 388.008.

#### 2.2.3 (SB 5) Sec. 388.004. Enforcement of Energy Standards Outside of Municipality

For construction outside of the local jurisdiction of a municipality, TERP provides for a building to comply if:

- a building certified by a national, state, or local accredited energy efficiency program shall be considered in compliance;
- a building with inspections from private code-certified inspectors using the energy efficiency chapter of the International Residential Code or International Energy Conservation Code shall be considered in compliance; and
- a builder who does not have access to either of the above methods for a building shall certify compliance using a form provided by the Laboratory, enumerating the code-compliance features of the building.

#### 2.2.4 (SB 5) Sec. 388.007. Distribution of Information and Technical Assistance

The Laboratory is required to make available to builders, designers, engineers, and architects code implementation materials that explain the requirements of the International Energy Conservation Code and the energy efficiency chapter of the International Residential Code. TERP authorizes the Laboratory to develop simplified materials to be designed for projects in which a design professional is not involved. It also authorizes the Laboratory to provide local jurisdictions with technical assistance concerning implementation and enforcement of the International Energy Conservation Code and the energy efficiency chapter of the International Residential Code.

#### 2.2.5 (SB 5) Sec. 388.008. Development of Home Energy Ratings.

TERP requires the Laboratory to develop a standardized report format to be used by providers of home energy ratings (HERs). The form must be designed to give potential buyers information on a structure's energy performance, including certain equipment. TERP requires the Laboratory to establish a public information program to inform homeowners, sellers, buyers, and others regarding home energy ratings.

#### 2.2.6 (HB 1365) Sec. 388.004. Enforcement of Energy Standards Outside of Municipality

At the 78<sup>th</sup> Legislature (2003), House Bill 1365 modified Section 388.004 of The TERP to include the following new requirements:

- That builders shall retain for three years documentation which shows their building is in compliance with the Texas Building Energy Performance Standards, and that builders shall provide a copy of the compliance documentation to homeowners.
- That single-family residences built in unincorporated areas of counties, which were completed on or after September 1, 2001, but not later than August 31, 2003, are considered in compliance with the Texas Building Energy Performance Standards.

To help builders comply with these requirements, the Laboratory will enhance the current form, which is posted on the Laboratory's The TERP website.

#### 2.2.7 (HB 1365) Sec. 388.009. Energy-Efficient Building Program

In 2003, House Bill 1365 modified the TERP, adding a new Section 388.009. In this section the General Land Office, the TCEQ and the Laboratory, working with an advisory committee, may develop an energy-efficient building accreditation program for buildings that exceed the building energy performance standards under Section 388.003 by 15% or more. This program shall be updated annually to include best available energy-efficient building practices. This program shall use a checklist system to produce an energy-efficient building scorecard to help: (1) home buyers compare potential homes and, by providing a copy of the completed scorecard to a mortgage lender, qualify for energy-efficient mortgages under the National Housing Act; and (2) communities qualify for emissions reduction credits by adopting codes that meet or exceed the energy-efficient building or energy performance standards established under this chapter. This effort may include a public information program to inform homeowners, sellers, buyers, and others regarding energy-efficient building ratings. The Laboratory shall establish a system to measure the reduction in energy and emissions produced under the energy-efficient building program and report those savings to the commission.

#### 2.2.8 (HB 3235) Sec. 388.009. Certification of Municipal Inspectors

Also in 2003, House Bill 3235 modified the TERP to add the new Section 388.009. In this section the Laboratory is required to develop and administer a state-wide training program for municipal building inspectors who seek to become code-certified inspectors. To accomplish this, the Laboratory will work with national code organizations to assist participants in the certification program and is allowed to collect a reasonable fee from participants in the

program to pay for the costs of administering the program. This program is required to be developed no later than January 1, 2004, with state-wide training sessions starting no later than March 1, 2004.

#### **2.2.9 (SB 20, HB 2481, HB 2129). Additional Energy-Efficiency Initiatives**

The 79<sup>th</sup> Legislature (2005), through SB 20, HB 2481 and HB 2129, amended SB 5 to enhance its effectiveness by adding the following additional energy-efficiency initiatives, including requiring 5,880 MW of generating capacity from renewable energy technologies by 2015, and 500 MW from non-wind renewables.

This legislation also requires PUCT to establish a target of 10,000 MW of installed renewable capacity by 2025, and requires TCEQ to develop a methodology for computing emissions reductions from renewable energy initiatives and the associated credits. The Laboratory is to assist TCEQ in quantifying emissions reductions credits from energy-efficiency and renewable-energy programs, through a contract with the Texas Environmental Research Consortium (TERC) to develop and annually calculate creditable emissions reductions from wind and other renewable energy resources for the state's SIP.

Finally, this legislation requires the Laboratory to develop at least 3 alternative methods for achieving a 15% greater potential energy savings in residential, commercial and industrial construction. To accomplish this, the Laboratory will be using the code-compliance calculator to ascertain which measures are best suited for reducing energy use without requiring substantial investments.

#### **2.2.10 (SB 12, HB 3693). Additional Energy-Efficiency Initiatives**

The 80<sup>th</sup> Legislature (2007), through SB 12, and HB 3693 amended SB 5 to enhance its effectiveness by adding several new energy efficiency initiatives. First, it requires the Laboratory to provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC), or the International Energy Conservation Code (IECC), are equivalent to or better than the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC. The laboratory shall make its recommendations not later than six months after publication of new editions at the end of each three-year code development cycle of the International Residential Code and the International Energy Conservation Code. As part of this work with SECO, the Laboratory is required to consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.

In addition, it requires the Laboratory to develop a standardized report format to be used by providers of home energy ratings, including different report formats for rating newly constructed residences from those for existing residences. The form must be designed to give potential buyers information on a structure's energy performance, including: insulation; types of windows; heating and cooling equipment; water heating equipment; additional energy conserving features, if any; results of performance measurements of building tightness and forced air distribution; and an overall rating of probable energy efficiency relative to the minimum requirements of the International Energy Conservation Code or the energy efficiency chapter of the International Residential Code, as appropriate.

It also encourages the Laboratory to cooperate with an industry organization or trade association to: develop guidelines for home energy ratings; provide training for individuals performing home energy ratings and providers of home energy ratings; and provide a registry of completed ratings for newly constructed residences and residential improvement projects for the purpose of computing the energy savings and emissions reductions benefits of the home energy ratings program. Finally, it requires the Laboratory shall include information on the benefits attained from this program in an annual report to the commission.

#### **2.2.11 (HB 1796). TERP Term & Additional Energy- Efficiency Initiatives**

The 81<sup>st</sup> Legislature (2009), through HB 1796, amended sections Sec. 386.252 (a) and (b), to extend the date of the TERP to 2019 and require the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

#### 2.2.12 (HB 51, SB 898, SB 924). Additional Energy-Efficiency Initiatives & Refinement of Ongoing Initiatives

The 82<sup>nd</sup> Legislature (2011) through HB-1, had an overall appropriation/budget reduction for TERP by 50%, (to take into effect in FY 2012). The Laboratory's funding under TERP were cut by 50% accordingly, while the Laboratory's responsibilities under TERP increased:

The 82<sup>nd</sup> Legislature (2011), through SB 898, amended Sec 388.005 (c), (d) and (e), which per the amendment, requires each political subdivision, institution of higher education or state agency to establish a goal to reduce the electric consumption by the entity by at least 5% each fiscal year for 10 years, beginning September 1, 2011. SB 898 further elaborated and enhanced the annual reporting requirements for those entities, and required SECO to develop a standardized form for reporting. SB 898 adds the Laboratory as the entity in charge of calculating energy savings and estimated emissions reduction for each political subdivision, institution of higher education or state agency, based on the information collected by SECO. The Laboratory shall share the analysis with the TCEQ, EPA and ERCOT.

The 82<sup>nd</sup> Legislature (2011), through SB 924, amended Sec 39.9051, Utilities Code, (f), (g) and (h), to enhance the reporting requirements by all municipally owned utilities and electric cooperatives that had retail sales of more than 500,000 MWh in 2005, regarding combined effects of their energy efficiency activities. Per the amended sections, beginning April 1, 2012, these entities must report each year to SECO, on a standardized form developed by SECO. The report of information regarding the combined effects of the energy efficiency activities of the electric cooperative/utility from the previous calendar year should include the annual goals, programs enacted to achieve those goals, and any achieved energy demand or savings goals. SB 924 adds the Laboratory as the entity in charge of calculating energy savings and estimated emissions reduction for municipally owned utilities and for electric cooperatives, based on the information collected by SECO. The Laboratory shall share the analysis with the PUCT, ERCOT, EPA and TCEQ.

The 82<sup>nd</sup> Legislature, through HB 51, required SECO to appoint a new advisory committee for selecting high-performance building design evaluation systems. The committee includes a representative from the Laboratory and meets at least once every two years.

The 82<sup>nd</sup> Legislature, through HB 51, modified Sec 388.003 (e) on the Laboratory's review of proposed local code amendments, which should be compared to the unamended code (instead of the "base" code), and added to Sec 388.007 (c) the fact that Laboratory is allowed to provide technical assistance concerning the implementation of local code amendments.

In addition, HB 51 added Sec 388.007 (d), which allows The Laboratory to conduct outreach to the real estate industry on the value of energy code compliance and above code construction.

### 3. Progress: January 2012 through December 2012

#### 3.1 (SB 5) Section 386.205. Evaluation of State Energy-Efficiency Programs (w/PUCT)

##### 3.1.1 Implemented Procedures for Evaluating State Energy-Efficiency Programs

In 2004 the Laboratory held several meetings with the Public Utility Commission of Texas to discuss the development of a framework for reporting emissions reduction from the State Energy Efficiency Programs administered by the PUCT. The State Energy-Efficiency Programs administered by the PUCT include programs under Senate Bill 7 (i.e., Section 39.905 Utilities Code) and Senate Bill 5.



In 2003 and 2004, the Laboratory worked with the TCEQ to identify a method to help the PUCT more accurately report their deemed savings as peak-day savings in 1999, using the Laboratory's new emissions reductions calculator. In 2005, this method was implemented in the TCEQ's Integrated Emissions Calculations, which was reported in the 2005, 2006, 2007, 2008, 2009 and 2010 annual report.

### 3.2 (SB 5) Sec. 388.003. Adoption of Building Energy-Efficiency Performance Standards

#### 3.2.1 Provide Code Training Sessions

During the 77<sup>th</sup> Legislature, Senate Bill 5 (SB 5) adopted the 2000 International Residential Code (IRC) as the energy code for single-family residential construction and the 2000 edition of the International Energy Conservation Code (IECC), with the 2001 Supplement for all other residential, commercial and industrial construction in the state. It requires that municipalities establish procedures for administration and enforcement, and ensure that code-certified inspectors perform inspections.

These codes are published by the International Code Council (ICC), which publishes a new edition every three years and a supplement in the intervening years. The 2003 Codes have been reviewed and determined to be no less stringent than the editions currently adopted by SB 5. Transition to the 2003 IRC and IECC can be easily accomplished. The 2006 Codes were reviewed and the residential provisions were determined to be less stringent than the editions adopted by SB 5 while the commercial provisions were determined to be as stringent as those in SB 5. Energy System Laboratory has assisted the local legislative bodies with amendments to the residential portions of the 2006 International Energy Conservation Code to insure it remains in compliance with the State Regulations concerning stringency.

Section 388.009 requires the Laboratory to develop and administer a state-wide training program for municipal building inspectors who seek to become code-certified inspectors. To accomplish this, the Laboratory developed the Energy Code Workshops which are based on the 2003 and 2006 International Energy Conservation Code (IECC) as published by the International Code Council (ICC) for residential and commercial buildings, with amendments. In addition, three more workshops were developed that offered software training, ASHRAE Standard 62.1 and ASHRAE Standard 90.1.

The Residential Energy Code Training Workshop and Commercial Requirements of the International Energy Conservation Workshop both include an overview of the TERP program and extensive instruction on all chapters of the IECC, which include the general requirements, definitions, and design conditions. The 2003 and 2006 Residential Workshops also includes detailed instruction on Chapter(s) which contain specific regulations relating to residential construction, in addition to a comparison of the IECC and the energy provisions of the International Residential Code (IRC). The 2003 and 2006 Commercial Workshops includes detailed instruction on Chapter(s), which relate to commercial regulations and a summary of the relationship between ASHRAE 90.1 and the commercial provisions of the IECC.

In 2011, the TERP group prepared new/revised materials for the following trainings:

- ☐ The 2009 IECC training materials created for the TWC workshops in 2010/2011, were updated and consolidated into two full length workshops, one for Residential and one for Commercial.
- ☐ ASHRAE Standard 90.0-2010 full-day workshops training materials, including PPT presentation and hard copy handouts
- ☐ The materials that were developed for the ASHRAE Standard 90.0-2010 full-day workshops (seven workshops delivered in 2011 and two in 2012) were also adapted for a series of five 45-minute online sessions that were filmed during the first quarter of 2012.

#### 3.2.2 Summary of ASHRAE Standard 90.1 Standards Committee Activities during 2012, and Ongoing Subcommittee Actions

The following paragraphs track the changes and discussion in the ASHRAE 90.1 Standard at the ASHRAE winter conference in and ASHRAE summer conference in. Both the conferences took place in 2012.

#### 1.1.1.1 SSPC 90.1 at the ASHRAE Winter Conference in Chicago, Illinois, January 21-23, 2012

##### THE NEW 2013 VERSION of ASHRAE 90.1:

A new energy savings target was set for the 1013 version of ASHRAE Standard 90.1. The goal is that this new release of 90.1-2013 will have 50% energy savings compared to the 2004 version. A Progress Indicator Report was made by Bing Liu (of Pacific Northwest National Laboratory) that shows energy savings impacts of the new standard on 16 different building types analyzed in 17 different climate zones. Generally, the report indicates that the savings goal of 50% may be hard to reach. The analyses so far show a national-weighted average savings of 33.8%. Further work that looked at recent Addenda shows that once applied, the savings could reach around 53.2% after changes in Envelope, Lighting and Mechanical updates are applied.

##### ADVANCED ENERGY STANDARD WORKING GROUP (WG):

There is an advanced working group, chaired by Drake Erbe, that is undertaking various tasks to see what innovative ideas could be applied to various building components that could result in further energy savings. Committee members were asked to sign up for numerous work tasks and report at future meetings.

##### SUBCOMMITTEE REPORTS:

##### ENVELOPE ISSUES:

- a) Report by Michael Waite. The subcommittee proposed envelope conditions for a modified App C, ECB and App G simulations – in lieu of using EnergyPlus or DOE-2. This would mean revisions to both Appendix C (Envelope trade-off) & ECB analyses. Occupancy schedules would reference the ventilation standard 62.1-2010. This new analysis procedure would be a simplified Trade-off program similar to COMcheck.
  - i) Baseline buildings would use the required UF & SHGC and  $VT=1.1*SHGC$ .
  - ii) Perimeter zone would have at least 50% of the LPD controlled by daylighting dimmers. Perimeter zone area would be calculated as the minimum of the whole floor area or  $1.25*$  wall area.
- b) There were a number of comments from unresolved commenters and objectors: Envelope topic -- Increase in roof insulation in metal buildings (from R-20 to R-30), commenter claims that this increases cost by \$1.30/sq.ft. Problem presented about purlins being shallower than the insulation depth required to meet the new R-values. Third commenter requested that the committee consider performance based criteria for the standard (i.e., a Building Energy Performance Standard.) Fourth commenter presented a detailed discussion on cost analyses on investment vs. benefit impacts – perceived problems w.r.t. rental viability. Fifth commenter (from TC-4.4) challenged the basis of the wall insulation cost data, asserting that it is out of date as much as 13 years and that costs are underestimated and savings are overestimated. [Note: Committee is undertaking an update to the LCC cost data bases to derive new economic scalars.]
- c) There was a vote taken to revise Appendix C, which includes changes to building envelope material values and schedules for occupancy and internal loads. This vote passed and will show up later as an Addendum to be voted on in the public review process. Passing of this will impact parts of section 5.6.1 and App C1, C3.
- d) Another proposal from the ENV subcommittee involved some changes in the definitions section relating to roof-top monitors, clerestory, etc. when defining daylight areas. Will be out as an addendum for a public review.

##### ECB ISSUES:

Discussions related to VAV fan power, Chapter 11, Table 11.3.2A – Footnote d. Committee proposed a change on allowing constant volume modeling for exception (b) in Section 6.5.2.1. Discussion ensued and the motion was finally withdrawn.

The committee also considered a proposal to allow credit for reduced infiltration in Chapter 11 & Appendix G. No final vote was taken on this.

Chairperson, Jason Glazer, revealed some of the recent updates of the active working Groups in the ECB SC and their cognizant leaders:

- Active addenda to 11 or G
  - CI - Cooling towers (March 25 - May 9) No comments
  - C - Lab exhaust fan (May 6 - June 5) No comments
  - E - Existing building envelope (Mar 25 - May 9) No comments
  - CG - Lighting (May 6 - June 20) No comments
  - CJ - Datacenters (June 10 - July 25) No comments
  - D - Orientation (Mar 25 - Apr 24) 1 comment - Rosenberg (draft). The comment responses still need to be posted or confirmed by Glazer and approved by Skalko.
  - W - Renewables (June 10 - July 25) 3 comments – Brundage. The comment response still need to be posted or confirmed by Glazer and approved by Skalko.
  - Ready for first public review: AI - Related to O, M, CY; AG - Air leakage; AH – Dehumidification. The public review for these has been delayed due to a delay in the balloting of SSPC members not present at the October meetings.
  - Ready for second public review: F - Percent glazing baseline (PRD1 - Mar/Apr 2011) – Rosenberg; R - Schedule conflict and non-standard HVAC (PRD1 June/July 2011) – Taber
- Actions before full committee
  - ECB01 - McEwin Request for Interpretation - Douglas (draft). Presented to SSPC. The SSPC approved by voice vote.
  - ECB02 - VAV fan part load performance (Table 11.3.2A footnote > d), never got updated when chapter 6 reduced the threshold > for VFDs from 25 hp to 10 hp - Rosenberg (draft). During discussion at the SSPC, ECB02 was withdrawn so that it better coordinates with MSC08. It was incorporated into MSC08 by voice vote at the SSPC. The combined MSC08/ECB07 passed the SSPC 37-0-0-CNV subject to continuation ballot. This will be Addenda AQ.
- Leslie Baseline Building Heating Selection CMP (Rosenberg, Brundage, Beilman, Leslie, Foster (draft))
  - Discussion of latest draft and issue of using propane as a fuel source. The issue of the definition of "fuel" is more complex and may be addressed separately by Brundage.
  - Do we need a definition of "building area type." Motion to recommend public review and publication by Rosenberg/Brundage passed 7-0-0. Don and Neil to make presentation to SSPC. The SSPC passed the motion 31-1-5 which passes subject to continuation ballot. This will be Addenda AL.
  - Brundage drafted a response to the CMP. "Motion by Brundage/Rosenberg passed 5-0-0. The SSPC approved the response by voice vote.
- Prescriptive Plus CMP (Rosenberg, Taber, Hintz, Glazer, Eley (draft))
  - Rosenberg provided new draft. The next EA TAG meeting will not be until after these meetings and Rosenberg will try to solicit feedback. Several important members of the EA TAG support the change. Suggestions that we should we break out the individual portions so they get through public review: modeler certification, compliance path, alternative metric, using 2004 as baseline.
  - Motion to "support in principal the concept of using 2004 as a fixed baseline for Appendix G" made by Glazer/Tillou. Passed 7-0-0.
  - Motion to "support in principal the concept of using a modified Appendix G as an alternative compliance path" made by Glazer/Tillou. Passed 7-0-0.
  - This was discussed further and issues were raised by McGuir about how suitable it would be to 189.1. We need to meet with 189.1 working group.
- Walsh CMP (Talbert (draft))
  - Talbert had conference call on Jan 11 with McBride and Erbe. Mechanical is taking the lead. The document reviewed. Motion to approve this portion of the response to Walsh made by Brundage/Talbert. The vote passed 5-0-0. It will be incorporated with responses

- from other subcommittees. The combined response from envelope, ecb and mechanical passed by voice vote.
- Supply-to-space temperature difference when zones are at different setpoints (Hintz (draft))
  - The proposal from August was reviewed. A question was raised if it should just be in the user's manual.
- Response to Moore CMP 0001/002 on infiltration (Tillou)
  - Reviewed the draft. Motion to recommend response of reject. Tillou/Hintz. Motion passed 7-0-0. SSPC approved response by voice vote.
- Packaged System Fan Power and removing power from EER for simulation (Tillou, Maor, Rosenberg, Douglas, Beilman (draft))
  - Reviewed latest draft from Beilman. Motion to recommend this for public review and publication by Brundage/Tillou. Motion passed 6-0-0. Concerns were raised by a subcommittee member prior to presenting to the full committee so it was not brought forward for a vote at the SSPC.
- Window Switches (Hintz, Stein)
  - Penalty for operable windows without switches and a credit for operable windows with switches. The switches reduce the conditioned air flow to the space. Question if bulk airflow model is needed to evaluate properly. Working group formed with Hintz, Taber, Beilman, Talbert, Stein with Hintz as leader.
- Review Addenda from 2007-2010 cycle to see if G or 11 need changes
  - Addenda h Dual Min Zone Controls (Maor)
  - Addenda n Single zone VAV (Talbert, Glazer (draft))
  - Addenda af/cc Pipe sizing (Rosenberg (draft))
  - Addenda as Lab Exhaust (Brundage, Maor)
  - Addenda bn Fenstration orientation (Glazer)
  - Addenda bs Receptacle (Taber (draft))
  - Addenda bx VAV Htg Temps (Maor)
  - Addenda ct Daylighting threshold (Tillou)
  - The following are waiting on a responds from Lighting (Tillou, White, Lane): Addenda al skylights in large enclosed spaces; and Addenda dd Toplighting.
  - The following are part of dehumidification addenda: Addenda b vivariums; and Addenda c Vivariums.
  - The following is part of the data center addenda CJ: Addenda bu Data centers

#### MECHANICAL ISSUES:

Chairperson, Martha VanGeem, revealed some of the recent updates of the active working Groups in the MSC and their cognizant leaders:

- Duct Insulation WG – Harry Misuriello
- Data Center WG (Ned Heminger)
  - Data Center WG has been meeting and reviewing CMP's as requested by MSC. Plan to have reviews complete as well as an internally generated proposal developed.
- Terminal Box Leakage WG (Jeff Boldt)
  - Responses to comments voted on by SSPC for Addendum x. Resulting in an ISC.
- Controls WG (Tim Peglow)
  - Addendum aa – further discussions to take place with commenter.
- Elevators WG (Jeff Boldt)
  - This was to come to the MSC in April.
- Thermal Storage WG – Steve Rosenstock
- Hydronics WG (Jeff Boldt)
  - No activity at this time.
- Laboratory WG (Ned Heminger)
  - No activity at this time.
- Healthcare WG (Jeff Boldt)
  - Discussed possible proposal on leakage requirements for rooms required to maintain pressure relationships with adjacent spaces. Will be taken up at the subcommittee's

- spring interim meeting.
- Chiller Plant WG (Frank Morrison/Susanna Hanson)
  - Reported as part of MSC proposal HVAC-15.
- Heat Recovery WG (Susanna Hanson)
  - Reported as part of MSC proposal HVAC-17.
- Filter WG (Tim Peglow)
- Economizer WG (Dick Lord - Susanna)
- Radiant Heating/Cooling WG (Richard Watson)
  - Motion MSC 19 (addendum “ap”) to submit a Continuous Maintenance Proposal (CMP) for publication and public review. Proposal is to add a new alternative compliance path for data centers (proposed by TC-9.9.) Refers to new limits on the PUE (power usage effectiveness) numbers.  $PUE = \text{Total load} / \text{IT load ratio}$ . Impacts Section 6.6.1 Computer Room Systems. New table showing different PUE limits in each climate zone.
  - Motion MSC 22: Proposed addendum “at” to reduce the economizer requirement to 5 tons, also limits on VAV fan motor sizes ( $<3/4$  h.p.) in Fan Power Limitations section. Also ECB CMP proposal on VAV Fan Power, Chapter 11.
  - MSC 07: Commercial refrigeration proposal. Intent is to meet new federal standards on walk-in coolers and freezers, to update a number of definitions of same, set requirements for condenser motor efficiencies, and to include requirements for closures. Discussion included comments about addressing the “R” in ASHRAE, and under the topic of HVAC&R that refrigeration and air conditioning are increasingly becoming converging technologies. So, refrigeration might need to be addressed with more stringency in the energy standards. Motion was passed to accept Addendum “ar” CMP for publication and public review.
  - Motion 25. Section 6.5.2.4. Proposal on insulation of heat exchanger tubes, humidifier, preheating jackets, etc. Recommendation is for an R-value of at least 0.5. Vote passed for publication and public review.
  - Motion CC-01. Combo committee CMP proposal from MSC/ENV/LTG. Response to a CMP submitted from outside, to reject comment alleging the need to clarify the reference to the proper weather data to use.

#### LIGHTING ISSUES:

Lighting Motion 18 (addendum “ao”) was proposed to submit a CMP (for publication and public review) that would replace the whole-building method (which is now section 9.5), by creating Section 9.3 called “Simplified method for whole buildings”, utilizing information from the AEDG booklets. This would add Table 9.3.1, “Whole Building Method Lighting Criteria” with new LPDs and control requirements for each of the building types. It would also include exterior lighting LPDs and controls. Motion was passed by the full committee.

#### 1.1.1.2 SSPC 90.1 at the ASHRAE Summer Conference in San Antonio, Texas, June 23-25, 2012

#### ECB ISSUES:

Chairperson, Jason Glazer, revealed some of the recent updates of the active working Groups in the ECB SC and their cognizant leaders:

- Baseline to 2004 proposal (Rosenberg)
  - Editorial changes made during meeting. Motion for publication and public review by Rosenberg seconded by Brundage passed 8-0-0. Note: The SSPC approved this for publication and public review by the vote 26-1-4. It will be Addendum BM.



- Packaged System Fan Power and removing power from EER for simulation (Tillou, Maor, Rosenberg, Douglas, Beilman (draft))
  - On Friday evening, Beilman reviewed proposal with subcommittee. Revised language during discussion. Motion for publication and public review made by Tillou and seconded by Douglas. Motion passed 7-0-0. Issues uncovered prior to presentation to SSPC on Saturday. During Saturday ECB meeting revised language further. Motion for publication and public review made by Rosenberg and seconded by Brundage. Motion passed 8-0-0. Note: The SSPC passed Motion 19 by the vote 23-2-5 subject to continuation ballot. This will be Addendum BL.
- COMNET sections in Appendix G - plug loads, refrigeration, tolerances around 140 tests, outdoor lighting schedules, TOU energy costs, equipment curves (Douglas, Rosenberg, Cherniack, Contoyannis)
  - Contoyannis spoke about COMNET and announced that the 2010 version will be out soon and the interest in parts of it becoming an ANSI standard. COMNET was funded by the Energy Foundation through New Buildings Institute. They are still determining if they want to submit CMPs to 90.1 or if they should be independent standards.
- Section 6.5.3.1 and Section 11.3.2.h (Douglas)
  - No change needed. Existing language was worded to not allow gaming on belt losses. Douglas will discuss with original person that noticed the difference.
- Table G3.1-5b Edits from Hogan (Beilman (draft))
  - Beilman will review Addendum E and see if it changes the proposed edits.
- Window Switches (Hintz, Stein)
  - Tillou volunteered to do some analysis on this topic. Tillou was added to working group.
- Parallel Fan Powered Boxes (Hintz (new report))
  - Faris made unscheduled presentation related to proposals he had submitted Friday morning. Hintz and Beilman will work on this. Need to coordinate with mechanical subcommittee on this change.
- Kitchen Hoods (Beilman)
  - Beilman will review language submitted by Stein related to Title 24 revision.
- Review Addenda from 2007-2010 cycle to see if G or I need changes
  - Addenda h Dual Min Zone Controls (Maor)
  - Addenda n Single zone VAV (Talbert, Glazer (draft))
  - Addenda af/cc Pipe sizing (Rosenberg (draft))
  - Addenda as Lab Exhaust (Brundage, Maor)
  - Addenda bn Fenstration orientation (Glazer)
  - Addenda bs Receptacle (Taber (draft))
  - Addenda bx VAV Htg Temps (Maor)
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  - The following are part of dehumidification addenda: Addenda b vivariums; and Addenda c Vivariums.
  - The following is part of the data center addenda CJ: Addenda bu Data centers

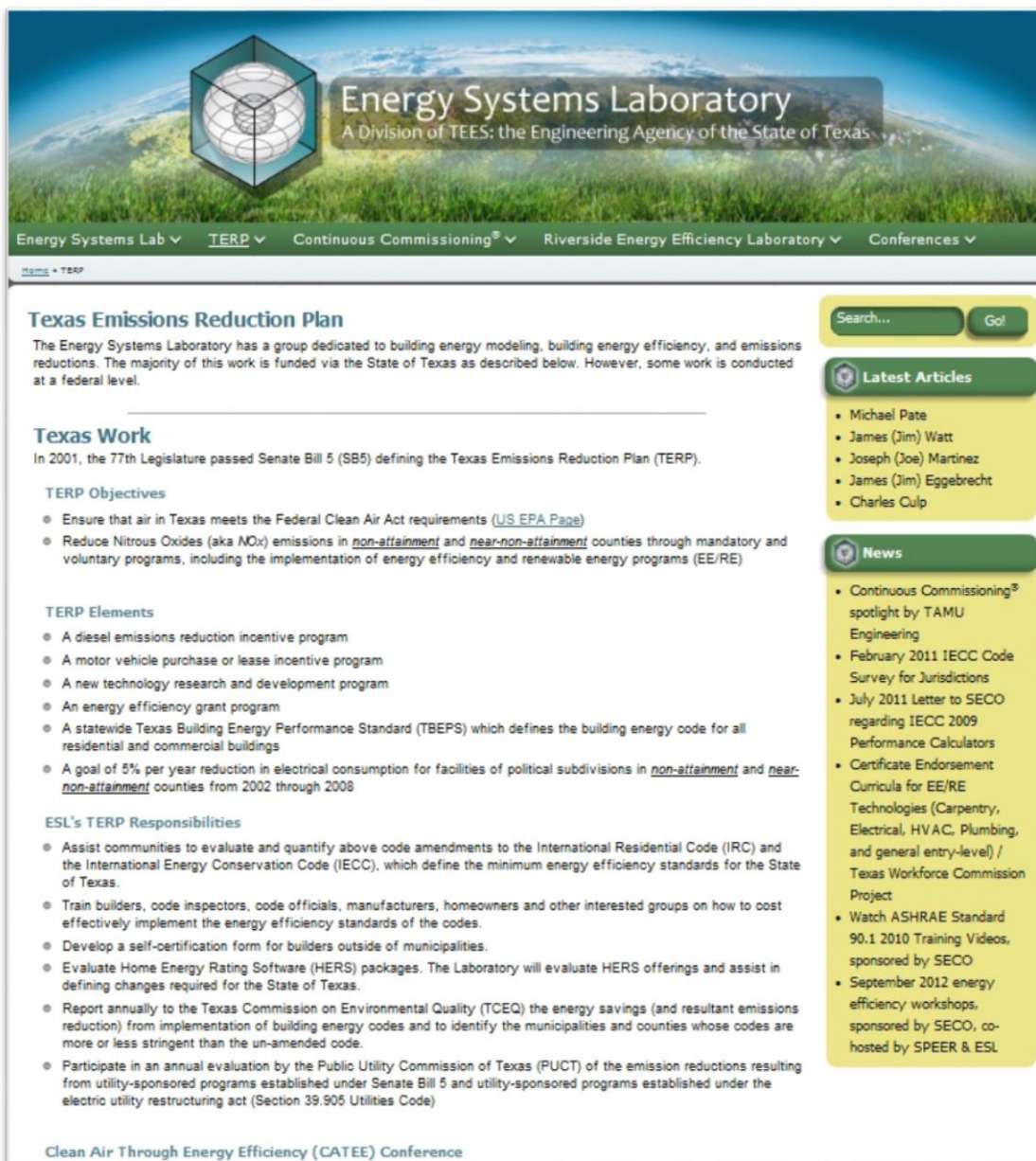
### 3.3 Laboratory's TERP Web Site "esl.tamu.edu/terp"

Since the fall of 2001, the Laboratory has maintained a TERP webpage, where information is provided to builders, code officials, the design community and homeowners about TERP. In 2010, the Laboratory redesigned its website to make navigation easier. On the navigation bar is a tab that links to the TERP homepage (Figure 28). The homepage contains the following items:

- Definition of the Texas Emissions Reduction Plan
- Texas Work
  - TERP Objectives

- TERP Elements
- ESL's TERP Responsibilities
- The CATEE Conference
- Links to
  - Texas Legislative Testimony by the ESL
  - TERP Legislative History
- National Work
  - National Center of Excellence on Displaced Emission Reductions (CEDER)
  - Links to
    - CEDER Program
    - EPA Recognizes ESL and Dallas Partners

In addition, the TERP homepage also includes a sidebar on the left with links to the latest articles and news.



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### Texas Emissions Reduction Plan

The Energy Systems Laboratory has a group dedicated to building energy modeling, building energy efficiency, and emissions reductions. The majority of this work is funded via the State of Texas as described below. However, some work is conducted at a federal level.

### Texas Work

In 2001, the 77th Legislature passed Senate Bill 5 (SB5) defining the Texas Emissions Reduction Plan (TERP).

#### TERP Objectives

- Ensure that air in Texas meets the Federal Clean Air Act requirements ([US EPA Page](#))
- Reduce Nitrous Oxides (aka NOx) emissions in non-attainment and near-non-attainment counties through mandatory and voluntary programs, including the implementation of energy efficiency and renewable energy programs (EE/RE)

#### TERP Elements

- A diesel emissions reduction incentive program
- A motor vehicle purchase or lease incentive program
- A new technology research and development program
- An energy efficiency grant program
- A statewide Texas Building Energy Performance Standard (TBEPS) which defines the building energy code for all residential and commercial buildings
- A goal of 5% per year reduction in electrical consumption for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2008

#### ESL's TERP Responsibilities

- Assist communities to evaluate and quantify above code amendments to the International Residential Code (IRC) and the International Energy Conservation Code (IECC), which define the minimum energy efficiency standards for the State of Texas.
- Train builders, code inspectors, code officials, manufacturers, homeowners and other interested groups on how to cost effectively implement the energy efficiency standards of the codes.
- Develop a self-certification form for builders outside of municipalities.
- Evaluate Home Energy Rating Software (HERS) packages. The Laboratory will evaluate HERS offerings and assist in defining changes required for the State of Texas.
- Report annually to the Texas Commission on Environmental Quality (TCEQ) the energy savings (and resultant emissions reduction) from implementation of building energy codes and to identify the municipalities and counties whose codes are more or less stringent than the un-amended code.
- Participate in an annual evaluation by the Public Utility Commission of Texas (PUCT) of the emission reductions resulting from utility-sponsored programs established under Senate Bill 5 and utility-sponsored programs established under the electric utility restructuring act (Section 39.905 Utilities Code)

Clean Air Through Energy Efficiency (CATEE) Conference

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#### Latest Articles

- Michael Pate
- James (Jim) Watt
- Joseph (Joe) Martinez
- James (Jim) Eggebrecht
- Charles Culp

#### News

- Continuous Commissioning® spotlight by TAMU Engineering
- February 2011 IECC Code Survey for Jurisdictions
- July 2011 Letter to SECO regarding IECC 2009 Performance Calculators
- Certificate Endorsement Curricula for EE/RE Technologies (Carpentry, Electrical, HVAC, Plumbing, and general entry-level) / Texas Workforce Commission Project
- Watch ASHRAE Standard 90.1 2010 Training Videos, sponsored by SECO
- September 2012 energy efficiency workshops, sponsored by SECO, co-hosted by SPEER & ESL

Figure 27. TERP Home Page

The TERP tab also contains a dropdown menu which provides links to the following sections

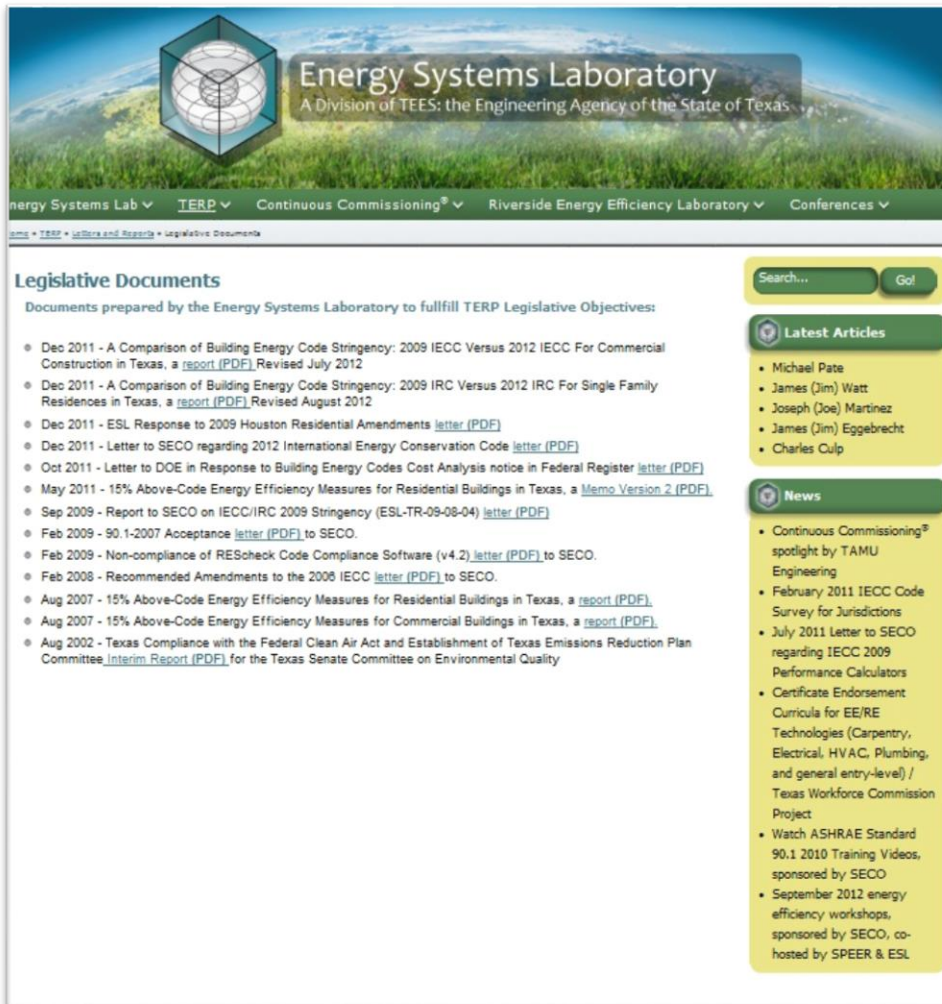


Figure 28: TERP –Letters and Reports

- Code Compliance Calculator
  - IC3
    - Help and Support – contains IC3 Help Resources including
      - Supplemental Release Notes
      - What’s New in this Version?
      - Manual
      - Detailed Release Notes for current release of IC3
      - Aggregate Reports from IC3 – Location, parameters and maps.
      - Contact information
      - Workshops
      - FAQ
      - RESNET Certification Resources
        - Report

- News – includes information about improvements and fixes to IC3 Workshops – description of IC3 Workshops, including contact information
  - FAQs
  - IC3 Reports – contains data from ESL’s research and software projects
    - IC3 – Registry House Parameters (updated monthly)
      - Envelope
      - Systems
      - Mixed
    - Texas Building Registry Demographics
      - Texas
      - Counties
      - Cities
      - TCV (Travis County & Austin)
    - Weather Data
  - TCV
    - Help & Support – contains TCV Help & Support and contact information
    - News – includes TCV News including
      - What’s New in Version 1.1
      - What is the Difference between TCV v1.1 and IC3 v3.x?
    - FAQs
  - Other Legacy calculators
    - AIM Calculator
    - eCalc 1.x Calculator
  - Credits
- Letters and Reports
  - Legislative Documents
  - Builders Information
  - EPA/CEDER Work
    - Background
    - Reports provided to US EPA as part of CEDER Program
  - Reports – listed by year from 2002-2012
- About
  - Legislative Testimony
  - Legislative Documents
  - Legislative History
- TERP Data Sets
  - Weather Data
  - Texas Building Registry
    - IC3/TCV Usage Reports
    - IC3 House Construction Trends
- TERP Links
  - eCalc Emissions & Energy Calculator
  - International Code Compliance Calculator (ICCC)
  - Public Utility Commission of Texas (PUC)
  - U.S. Department of Energy (DOE)
  - Texas State Conservation Office (SECO)
  - U.S. Environmental Protection Agency (EPA)
  - International Code Council (ICC)
  - American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
  - North Central Texas Council of Governments (NCTCOG)

- Alamo Area Council of Governments (AACOG)
  - Circle of Ten
  - Texas Home Energy Rating Organization (TxHERO)
- Other Publications
  - Builders Information
  - Digital Library
  - Presentations
  - Proceedings
    - Air Quality (CATEE)
    - Hot & Humid
    - IBPSA
    - ICEBO
    - IETC
- Workshops
  - IC3
  - IECC Residential
  - IECC Commercial
  - ASHRAE

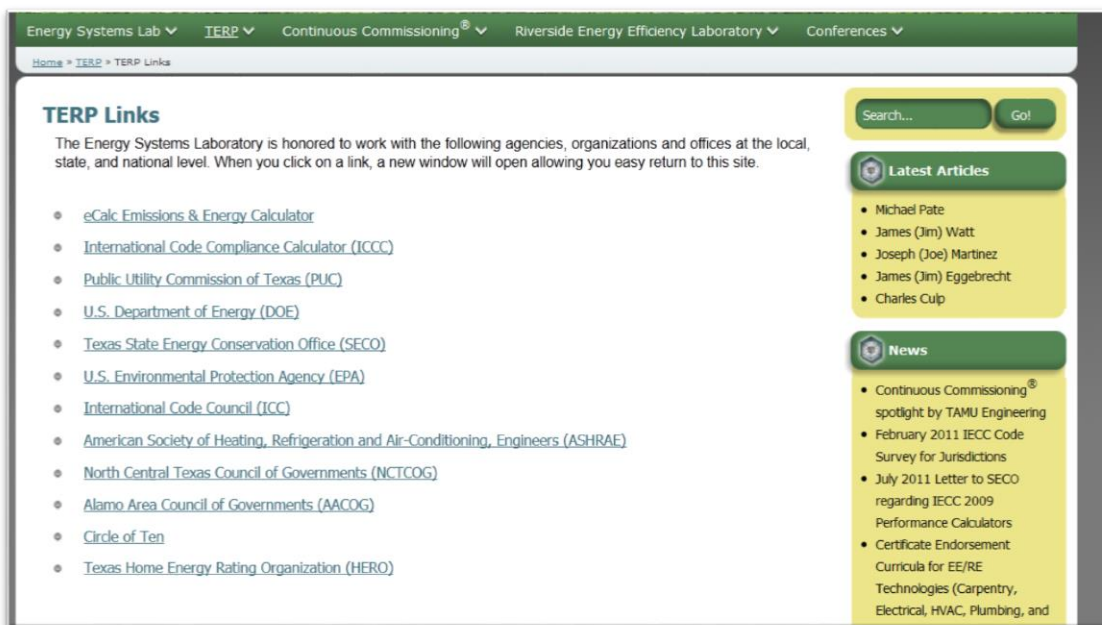


Figure 29: TERP Links



The Energy Systems lab also hosted the Clear Air Through Energy Efficiency Conference (CATEE)

## CATEE 2012 Program

Tuesday, Oct. 9 – Pre-Conference Workshops	
10:00am-12:00pm	<a href="#">New Funding Alternatives, Sources and Strategies To Create High-Performing, Energy Efficient Buildings</a> (.2 CEU/2 PDH)
1:00pm-5:00pm	<a href="#">School Energy Management</a> (.4 CEU/4 PDH)
1:00pm-5:00pm	<a href="#">Which Green Rating System is Right for You?</a> (.4 CEU/4 PDH)
Wednesday, Oct. 10 – Day One of Conference (.6 CEU/6PDH)	
7:30am	Registration opens
8:00am	Exhibits open
8:30am	<b>Opening Plenary:</b> <ul style="list-style-type: none"> <li>• Welcome Remarks &amp; Introductions               <ul style="list-style-type: none"> <li>• <i>The Honorable Lewis Rosen, Mayor of Galveston</i></li> <li>• <i>Dr. David Claridge, Director, Energy Systems Laboratory</i></li> </ul> </li> <li>• <a href="#">Electric Resources in Texas</a> - <i>Brian Lloyd, Executive Director, Public Utility Commission of Texas</i></li> <li>• <a href="#">Efficiency &amp; Demand Response</a> - <i>Paul Wattles, Sr. Analyst, Market Design, ERCOT</i></li> <li>• <a href="#">EPA Perspectives</a> - <i>Carl Edlund, Director, Multi-media Planning &amp; Permitting, USEPA Region 6</i></li> <li>• <a href="#">Keynote: Sustainability Leadership</a> - <i>Major General Dana J.H. Pittard, Commanding General, 1st Armored Division and Fort Bliss, TX</i></li> </ul>

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Figure 30: CATEE Conference

2012 Presentations	
<b>Arneson</b>	– Tremont House and Hotel Galvez Sustainability Modifications – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Bartel</b>	– Transforming the Future of Electric Distribution & Energy Consumption – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Brasora</b>	– City of Dallas Green Buildings Case Study – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Blake</b>	– Raising the Bar : Houston – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Brown</b>	– Success in School Energy Management – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Claridge</b>	– Reducing Energy Use with 50% ROI through Continuous Commissioning® – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Copithorne</b>	– On-Bill Repayment: A Proposal to Increase Investment in Texas – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Corbitt</b>	– Success in School Energy Management:Energy Monitoring – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>DuPlessis</b>	– Behavioral Modification – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Edlund</b>	– Texas Air Quality and the Role of Energy Efficiency – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Forrest</b>	– New Technologies That Work – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Fyock</b>	– Insight into Corporate Energy Management Trends: Focus on Texas – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Haberl</b>	– Emissions Reduction Impact of Renewables – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Haberl</b>	– EE/RE Impacts on Emission Reductions – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Hamilton</b>	– Combustion and Health – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Hanel &amp; Tyra</b>	– Oncor Energy Efficiency Programs Solar Photovoltaic - <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Hatcher</b>	– Application of CC at a Corporate Headquarters Facility in Dallas, TX – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Herweck</b>	– New Technologies That Work – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Heydinger</b>	– Energy Efficiency Financing: PACE – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Hildebrand</b>	– Texas Air Quality Status and the Texas Emissions Reduction Plan – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Jones</b>	– Comfort by Design – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Lloyd</b>	– Texas Electricity Update – <a href="#">PDF</a>
<b>Martin</b>	– Utility Goals for the – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Morrison</b>	– Smart Energy Presentation – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Neukomm</b>	– Better Buildings – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Pelz</b>	– The Green Revival Program – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>
<b>Peterson</b>	– Sustainability Engagement Strategy – <a href="#">PDF</a> , <a href="#">Slides/Audio</a>

Figure 30: CATEE Conference (continued)

### 3.3.1 Provide Technical Assistance to the TCEQ

The Laboratory received dozens of calls per week from code officials, builders, home owners and municipal officials regarding the building code and emissions calculations. A complete file of these transactions is maintained at the Laboratory.

### 3.4 Delivered “Statewide Air Emissions Calculations from Wind and Other Renewables: Summary Report September 2012 – July 2013,” to the Texas Commission on Environmental Quality in August 2013.

The Energy Systems Laboratory, in fulfillment of its responsibilities under this Legislation, submits its annual report, “Statewide Air Emissions Calculations from Wind and Other Renewables,” to the Texas Commission on Environmental Quality.

The report is organized in several deliverables:

- a summary report, which details the key areas of work
- supporting documentation
- supporting data files, including weather data, and wind production data, which have been assembled as part of the year’s effort

The executive summary provides summaries of the key areas of accomplishment this year, including:

- continuation of stakeholder’s meetings
- analysis of power generation from wind farms using improved method and 2011 and 2012 data
- analysis of emissions reduction from wind farms
- updates on degradation analysis
- analysis of other renewables, including PV, solar thermal, hydroelectric, geothermal and landfill gas
- review of electricity generation by renewable sources and transmission planning study reported by ERCOT

#### 3.4.1 Analysis of wind farms using improved method and 2011 and 2012 data

In this report, the weather normalization procedures, developed together with the Stakeholders, were presented and applied to all the wind farms that reported their data to ERCOT during the 2011 and 2012 measurement period, together with wind data from the nearby NOAA weather stations. In the 2011 Wind and Renewables report to the TCEQ (Haberl et al. 2011), weather normalization analysis methods were reviewed.

This report used the same analysis method as the previous 2010 report (Sweetwater III as an example) to present the same weather normalization procedure, including:

- the processing of weather and power generation data, modeling of daily power generation versus daily wind speed using the ASHRAE Inverse Model Toolkit (IMT) for two separate periods, i.e., Ozone Season Period (OSP), from July 15 to September 15, and Non-Ozone Season Period (Non-OSP);
- predicting 2008 wind power generation as a baseline, using developed coefficients from 2011 daily OSP and Non-OSP models for all the wind farms; and
- the analysis on monthly capacity factors generated using the models

A summary of total wind power production in the base year (2008) for all of the wind farms in the ERCOT region using the developed procedure is presented, and the new wind farms which started operation in 2011 were added, including Cedro Hill Wind, Loraine Windpark III and Papalote Creek Phase II. Figure 3-31 shows the measured annual wind power generation in 2011 and the estimated wind power generation in 2008 using the developed method for those wind farms in the ERCOT region. The total measured wind power generation in 2011 is 27,536,276 MWh/yr., which is 2.7% less than what the same wind farms would have produced in 2008. Figure 3-32 shows the same comparison but for the Ozone Season Period. The measured wind power generation in the OSP of

2011 is 57,096 MWh/day, which is 14.26% higher than the 2008 OSP baseline wind production. Especially for wind farms named BUFF\_GAP\_UNIT2 and SWEETWN3\_WND3, there are missing data period from January to June. Only six month wind power data available result in the huge difference between measured 2011 ERCOT wind power production and estimated 2008 wind power production.

This report also includes an uncertainty analysis that was performed on all the daily regression models for the entire year and Ozone Season Period. The detailed analysis for each wind farm is provided in the Appendix B to this report. The original data used in the analysis is included in the accompanying CD-ROM with this report.

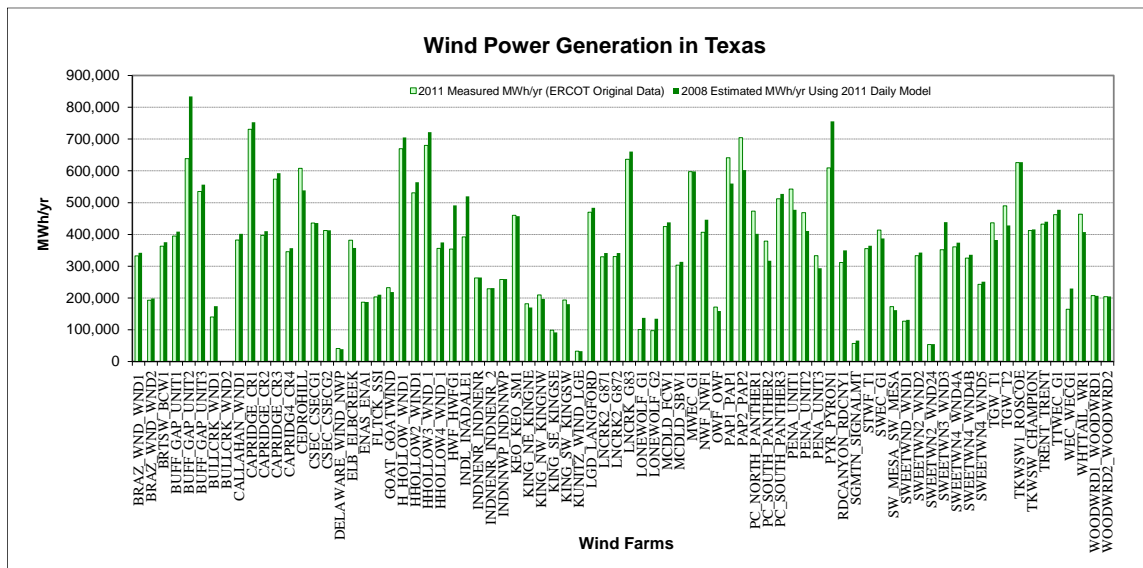


Figure 3-31: Comparison of 2011 Measured and 2008 Estimated Wind Power Production for Each Wind Farm

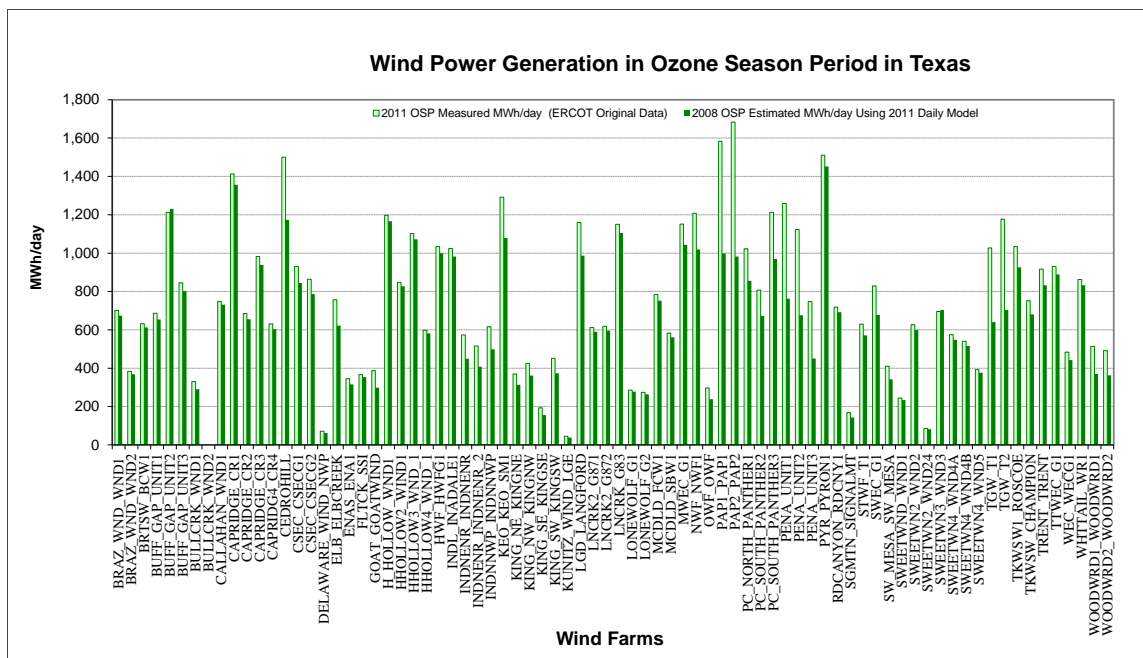


Figure 3-32: Comparison of 2011 OSP Measured and 2008 OSP Estimated Wind Power Production for Each Wind Farm

#### 1.1.1.3 Analysis of emissions reductions from wind farms

In this report, the procedure for calculating annual and peak-day, county-wide NO<sub>x</sub> reductions from electricity savings from wind projects implemented in the congestion management (CM) zones in ERCOT was presented and, calculating the NO<sub>x</sub> emission reductions based on the special version of 2010 eGRID, developed by the ESL and EPA for the TCEQ. According to the developed models, the total MWh savings for all the wind farms in the base year 2008 within the ERCOT region are 28,299,330MWh and 49,971MWh/day in the Ozone Season Period. The total NO<sub>x</sub> emissions reductions across all the counties amount to 7,745.15 tons/yr. and 13.69 tons/day for the Ozone Season Period. Based on the 2011 measured ERCOT data, the total MWh savings for all the wind farms within the ERCOT region are 27,536,276 MWh and 57,096 MWh/day in the Ozone Season Period. The total NO<sub>x</sub> emissions reductions in 2011 across all the counties amount to 7,569.94 tons/yr. and 15.81 tons/day for the Ozone Season Period. Compared to the base year 2008, the total annual NO<sub>x</sub> emissions reductions decreased by 2.26%, and the total NO<sub>x</sub> emissions reductions increase 15.5% for the Ozone Season Period.

#### 1.1.1.4 Development of a degradation analysis

This report contains an updated analysis to determine what amount of degradation could be observed in the measured power from Texas wind farms. Currently, the TCEQ uses a very conservative 5% degradation per year for the power output from a wind farm when making future projections from existing wind farms. Accordingly, the TCEQ asked the ESL to evaluate any observed degradation from the measured data for Texas wind farms. To accomplish this, forty three wind farms (38 sites) built from 2001 to 2011 were evaluated with a total capacity of 4,664.1 MW in this report. This year, twenty two qualified wind farms were added for the analysis because at least four- year measured data were required for the analysis.

In this analysis, a sliding statistical index was established for each site that used the 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup>, and 99<sup>th</sup> percentiles of the hourly power generation over a 12-month sliding period, as well as mean, minimum and maximum hourly power generation of the same 12-month period. These indices were then displayed using one data symbol for each 12-month slide, beginning from the first 12-month period until the last 12-month period for each of the wind farms.

Of the thirty eight sites analyzed, nineteen sites showed an increase when one compares the 90<sup>th</sup> percentile of the whole period to the 90<sup>th</sup> percentile of the first 12-month period, ranging from 0.1 % to 68%. The remaining nineteen sites showed a decrease from -0.5% to -32.6%. The weighted average of this increase across all wind farms studied is 5% (positive), which indicates that no degradation was observed from the aggregate energy production from these wind farms over the studied operation period. Based on the observations, special attentions need to be paid to site Buffalo Gap 1 (-17.9%), Big Spring Wind Power (-11.7%), Capricorn Ridge Wind (-10.4%), Snyder Wind Project (-17.1%), Texas Wind Power Project (-32.6%) and Whirlwind (-14.7). Those wind farms have comparison percentage larger than 10%, which may be caused by wind farm operations issues, the meter problems or other issues that have not been aware of.

#### 1.1.1.5 Analysis of other renewable sources

Other renewable energy projects throughout the state of Texas were located to determine NO<sub>x</sub> emissions reduction and are included in this section. Searches were conducted on five specific categories which include solar photovoltaic, solar thermal, geothermal, hydroelectric, and Landfill Gas-Fired Power Plants. Many newly located

renewable energy projects are assembled for inclusion in this report. NOx emissions reduction were calculated for only the solar photovoltaic and solar thermal projects.

County-wide NOx reductions from electricity savings from solar photovoltaic and solar thermal projects based on the special version of Texas 2010 eGRID. According to the developed models, the total energy savings for all the solar photovoltaic within the ERCOT region for the year 2012 were 176,311 MWh and 527 MWh/day in the Ozone Season Period. The total annual NOx emissions reductions across all the counties amount to 59.42 tons/yr and 0.178 tons/day for the Ozone Season Period. Similarly, the total MWh savings for all the solar thermal projects for year 2012 were 232 MWh and 1.0 MWh/day in the Ozone Season Period and the total NOx emissions reductions across all the counties amount to 0.072 tons/yr. and 0.00019 tons/day for the Ozone Season Period.

#### 1.1.1.6 Review of electricity savings and transmission planning study reported by ERCOT

In this report, the information posted on ERCOT's Renewable Energy Credit Program site [www.texasrenewables.com](http://www.texasrenewables.com) is reviewed. In particular, information posted under the "Public Reports" tab was downloaded and assembled into an appropriate format for review. This includes ERCOT's 2001 through 2012 reports to the Legislature and information from ERCOT's listing of REC generators.

Each year ERCOT is required to compile a list of grid-connected sources that generate electricity from renewable energy and report them to the Legislature. Table 3-1 contains the data reported by ERCOT from 2001- 2012. Figure 3-33 is included to better illustrate the annual data collected by ERCOT.

*Table 3-1: Annual Electricity Generation by Renewable Resources (MWh, ERCOT: 2001 - 2012)*

Technology Type	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Biomass	0	0	39,496	36,940	58,637	60,569	54,101	70,833	73,364	97,535	137,004	288,988
Hydro	30,639	312,093	239,684	234,791	310,302	210,077	382,882	445,428	507,507	609,257	267,113	389,197
Landfill gas	0	29,412	154,206	203,443	213,777	306,087	356,339	387,110	412,923	464,904	497,645	537,966
Solar	0	87	220	211	227	470	1,844	3,338	4,492	14,449	36,580	133,642
Wind	565,597	2,451,484	2,515,482	3,209,630	4,221,568	6,530,928	9,351,168	16,286,440	20,596,105	26,828,660	30,769,674	32,746,534
Total (MWh)	596,236	2,793,076	2,949,087	3,685,014	4,804,512	7,108,131	10,146,333	17,193,150	21,594,390	28,014,805	31,708,016	34,096,328



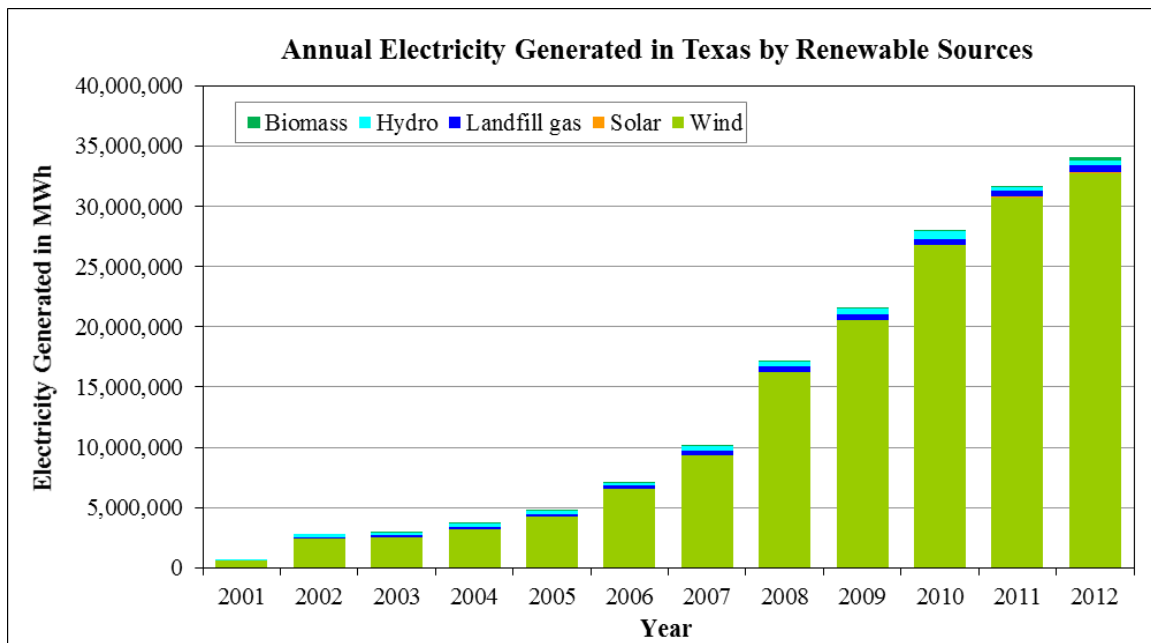


Figure 3-33: Electricity Generation by Renewable Resources (ERCOT: 2001–2012 Annual)

### 3.5 Technical Assistance

The Laboratory provides technical assistance to the TCEQ, the PUC, SECO and ERCOT, as well as Stakeholders participating in a number of conferences and presentations. In 2011, the Laboratory continued to work closely with the TCEQ to develop an integrated emissions calculation, which provided the TCEQ with a creditable NO<sub>x</sub> emissions reduction from energy efficiency and renewable energy (EE/RE) programs reported to the TCEQ in 2005, 2006, 2007, 2008, 2009, 2010 and 2011 by the Laboratory, PUC, SECO, and Wind-ERCOT.

The Laboratory has also enhanced the previously developed emissions calculator by: expanding the capabilities to include all counties in ERCOT, including the collection and assembly of weather from 1999 to the present from 17 NOAA weather stations, and enhancing the underlying computer platform for the calculator.

The Laboratory has and will continue to provide leading edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering the emissions and improving the air for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP.

**Table 1: 2000/2001 IECC Performance Path vs. 2009 IECC Performance Path**

County	IECC 2009 Weather Zones	Energy Type**	Total Annual Savings of the IECC 2009 Performance Path compared to the IECC 2000/2001 (%)*	
			Gas Heating, DHW	Heat Pump Heating, Electric DHW
<b>Houston (HAR)</b>	2A	Site	10.9 %	10.9 %
		Source	11.9 %	10.9 %
<b>Brownsville (CAM)</b>	2B	Site	16.4 %	13.6 %
		Source	15.1 %	13.6 %
<b>Dallas (TAR)</b>	3A	Site	12.8 %	10.8 %
		Source	12.3 %	10.8 %
<b>El Paso (ELP)</b>	3B	Site	10.2 %	10.0 %
		Source	11.2 %	10.0 %
<b>Amarillo (ARM)</b>	4B	Site	16.0 %	14.6 %
		Source	16.7 %	14.6 %

*\*Base-case Simulation Assumptions:* Analysis used single-family house, 2,500 ft<sup>2</sup>, single story, four bedrooms, slab-on-grade, ducts in the unconditioned, ventilated attic, window-to-floor ratio: 18% for 2000/2001, 15% for 2009, windows equally distributed (N,E,S,W), and no exterior shading. HVAC Distribution efficiency: 0.8 for 2000/2001, 0.88 for 2009. All other roof, wall and window parameters as per 2000/2001 and 2009 IECC for county shown (IC3 ver. 3.03.02).

*\*\*Source Energy Consumption:* A factor of 3.16 was used to calculate the source electricity consumption. A factor of 1.1 was used to calculate source gas energy consumption.

**Table 2: 2000/2001 IECC Performance Path vs. 2009 IECC Prescriptive Path**

County	IECC 2009 Weather Zones	Energy Type**	Total Annual Savings of the IECC 2009 Prescriptive Path compared to the IECC 2000/2001 (%)*	
			Gas Heating, DHW	Heat Pump Heating, Electric DHW
<b>Houston (HAR)</b>	2A	Site	7.8 %	8.7 %
		Source	9.1 %	8.7 %
<b>Brownsville (CAM)</b>	2B	Site	14.3 %	11.6 %
		Source	13.0 %	11.6 %
<b>Dallas (TAR)</b>	3A	Site	9.6 %	8.6 %
		Source	9.6 %	8.6 %
<b>El Paso (ELP)</b>	3B	Site	7.0 %	8.3 %
		Source	8.9 %	8.3 %
<b>Amarillo (ARM)</b>	4B	Site	10.7 %	11.9 %
		Source	13.1 %	11.9 %

*\*Base-case Simulation Assumptions:* Analysis used single-family house, 2,500 ft<sup>2</sup>, single story, four bedrooms, slab-on-grade, ducts in the unconditioned, ventilated attic, window-to-floor ratio: 18% for 2000/2001, 15% for 2009, windows equally distributed (N,E,S,W), and no exterior shading. HVAC Distribution efficiency: 0.8 for 2000/2001; for 2009 IECC, HVAC distribution efficiency simulated using R8 insulation for supply, R6 for return ducts and total duct leakage of 11% to outdoor. All other roof, wall and window parameters as per 2000/2001 and 2009 IECC for county shown (IC3 ver. 3.03.02).

*\*\*Source Energy Consumption:* A factor of 3.16 was used to calculate the source electricity consumption. A factor of 1.1 was used to calculate source gas energy consumption.

**Table 3: 2000/2001 IECC Performance Path vs. Chapter 11 of the 2009 IRC Prescriptive Path**

County	IECC 2009 Weather Zones	Energy Type**	Total Annual Savings of the IRC 2009 compared to the IECC 2000/2001 (%)*	
			Gas Heating, DHW	Heat Pump Heating, Electric DHW
<b>Houston (HAR)</b>	2A	Site	7.7 %	7.7 %
		Source	8.3 %	7.7 %
<b>Brownsville (CAM)</b>	2B	Site	13.7 %	10.4 %
		Source	11.8 %	10.4 %
<b>Dallas (TAR)</b>	3A	Site	9.9 %	7.8 %
		Source	9.0 %	7.8 %
<b>El Paso (ELP)</b>	3B	Site	7.1 %	7.1 %
		Source	7.9 %	7.1 %
<b>Amarillo (ARM)</b>	4B	Site	10.7 %	11.9 %
		Source	13.1 %	11.9 %

*\*Base-case Simulation Assumptions:* Analysis used single-family house, 2,500 ft<sup>2</sup>, single story, four bedrooms, slab-on-grade, ducts in the unconditioned, ventilated attic, window-to-floor ratio: 18% for 2000/2001, 15% for 2009 IRC, windows equally distributed (N,E,S,W), and no exterior shading. HVAC Distribution efficiency: 0.8 for 2000/2001; for 2009 IRC, HVAC distribution efficiency simulated using R8 insulation for supply, R6 for return ducts and total duct leakage of 11% to outdoor. All other roof, wall and window parameters as per 2000/2001 and 2009 IRC for county shown (IC3 ver. 3.03.02).

*\*\*Source Energy Consumption:* A factor of 3.16 was used to calculate the source electricity consumption. A factor of 1.1 was used to calculate source gas energy consumption.

### 3.6 Presentations to various entities and conferences.

The Energy Systems Laboratory made presentations at several conferences about ways to save energy.

Presentation to the City of Arlington, February 2012



Figure 34: Presentation to the City of Arlington

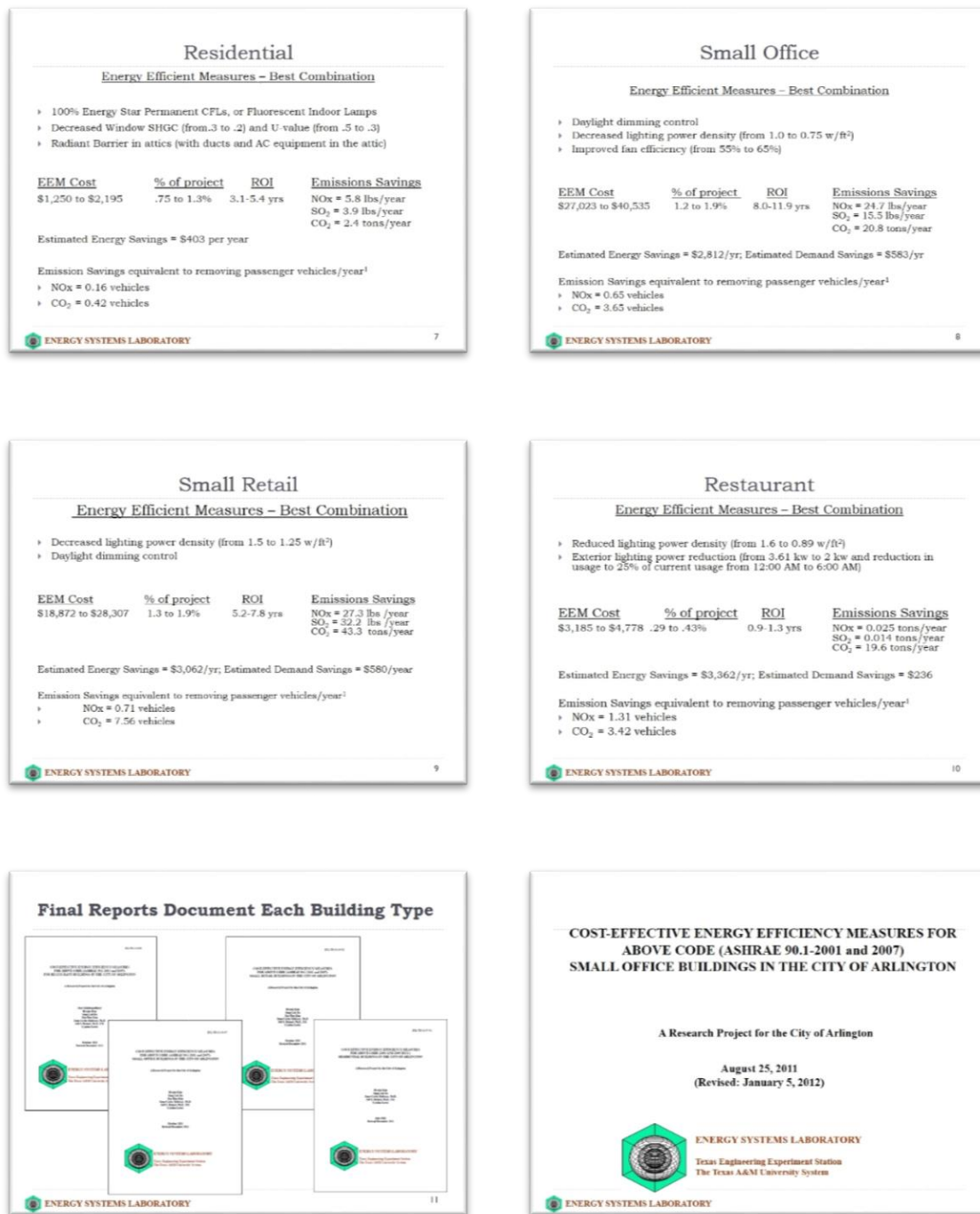


Figure 34: Presentation to the City of Arlington (Continued)

### Background

- Reviewed two years of building energy compliance reports from 2008 to 2010 for 11 commercial projects in the CoA.
  - Results of the review: Summary of above-code approaches that have been made in the CoA during the 2008-2010.
- Results of the current project: Recommendations of 17 energy efficiency measures (EEMs) to maximize energy savings for small office buildings in the CoA with
  - estimated cost of the improvement,
  - simple payback calculations, and
  - emissions savings.

ENERGY SYSTEMS LABORATORY 13

### Methodology

- ESL simulation model based on the DOE-2.1e of ASHRAE 90.1-2001 and 2007 code-compliant, small office building for Tarrant County
- A total of 17 energy efficiency measures (EEMs)
- Solar measures using PV-F Chart and F-Chart programs
- Implementation costs of each measure with simple payback

ENERGY SYSTEMS LABORATORY 14

### Methodology

- 20,000 ft<sup>2</sup>, square-shape, two-story, office building
- Wood frame construction
- 20% window-to-wall ratio
- Packaged rooftop air conditioner (CAV, DX, gas furnace)

Measure	Estimated Cost (\$)	Simple Payback (Years)	Annual Energy Savings (kWh)	Annual CO <sub>2</sub> Savings (lb)
1. High Albedo Roof	1,000	0.5	1,000	100
2. Low Emissivity Windows	2,000	1.0	2,000	200
3. High Albedo Roof	1,000	0.5	1,000	100
4. High Albedo Roof	1,000	0.5	1,000	100
5. High Albedo Roof	1,000	0.5	1,000	100
6. High Albedo Roof	1,000	0.5	1,000	100
7. High Albedo Roof	1,000	0.5	1,000	100
8. High Albedo Roof	1,000	0.5	1,000	100
9. High Albedo Roof	1,000	0.5	1,000	100
10. High Albedo Roof	1,000	0.5	1,000	100
11. High Albedo Roof	1,000	0.5	1,000	100
12. High Albedo Roof	1,000	0.5	1,000	100
13. High Albedo Roof	1,000	0.5	1,000	100
14. High Albedo Roof	1,000	0.5	1,000	100
15. High Albedo Roof	1,000	0.5	1,000	100
16. High Albedo Roof	1,000	0.5	1,000	100
17. High Albedo Roof	1,000	0.5	1,000	100

ENERGY SYSTEMS LABORATORY 15

### Methodology

- 17 EEMs for envelope and fenestration, HVAC System, service hot water (SHW) system, lighting and receptacle, and renewable measures

EEM No.	EEM Description	Estimated Cost (\$)	Simple Payback (Years)	Annual Energy Savings (kWh)	Annual CO <sub>2</sub> Savings (lb)
1	High Albedo Roof	1,000	0.5	1,000	100
2	Low Emissivity Windows	2,000	1.0	2,000	200
3	High Albedo Roof	1,000	0.5	1,000	100
4	High Albedo Roof	1,000	0.5	1,000	100
5	High Albedo Roof	1,000	0.5	1,000	100
6	High Albedo Roof	1,000	0.5	1,000	100
7	High Albedo Roof	1,000	0.5	1,000	100
8	High Albedo Roof	1,000	0.5	1,000	100
9	High Albedo Roof	1,000	0.5	1,000	100
10	High Albedo Roof	1,000	0.5	1,000	100
11	High Albedo Roof	1,000	0.5	1,000	100
12	High Albedo Roof	1,000	0.5	1,000	100
13	High Albedo Roof	1,000	0.5	1,000	100
14	High Albedo Roof	1,000	0.5	1,000	100
15	High Albedo Roof	1,000	0.5	1,000	100
16	High Albedo Roof	1,000	0.5	1,000	100
17	High Albedo Roof	1,000	0.5	1,000	100

ENERGY SYSTEMS LABORATORY 16

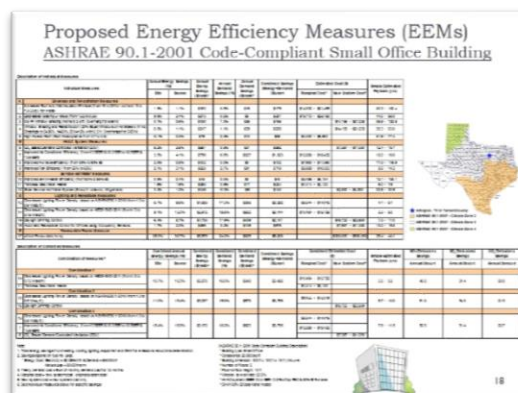
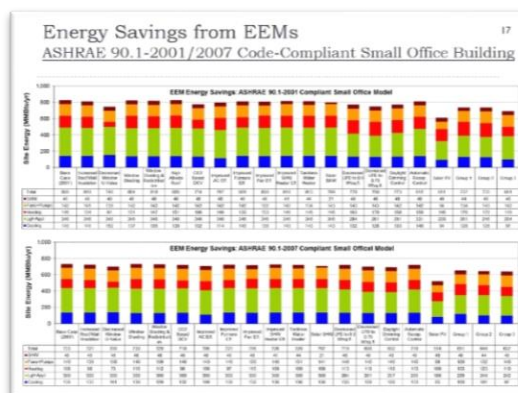


Figure 34: Presentation to the City of Arlington (Continued)





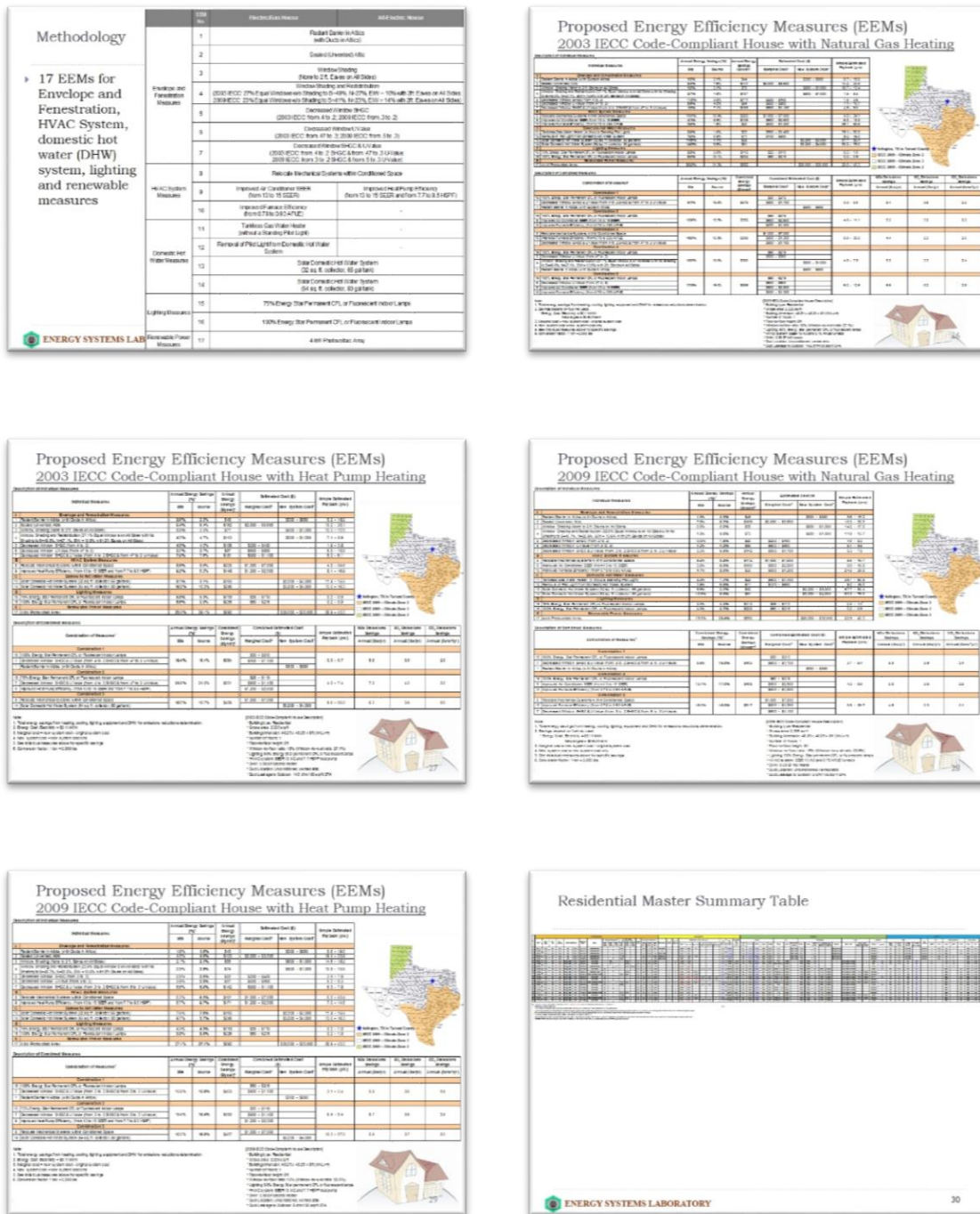


Figure 34: Presentation to the City of Arlington (Continued)

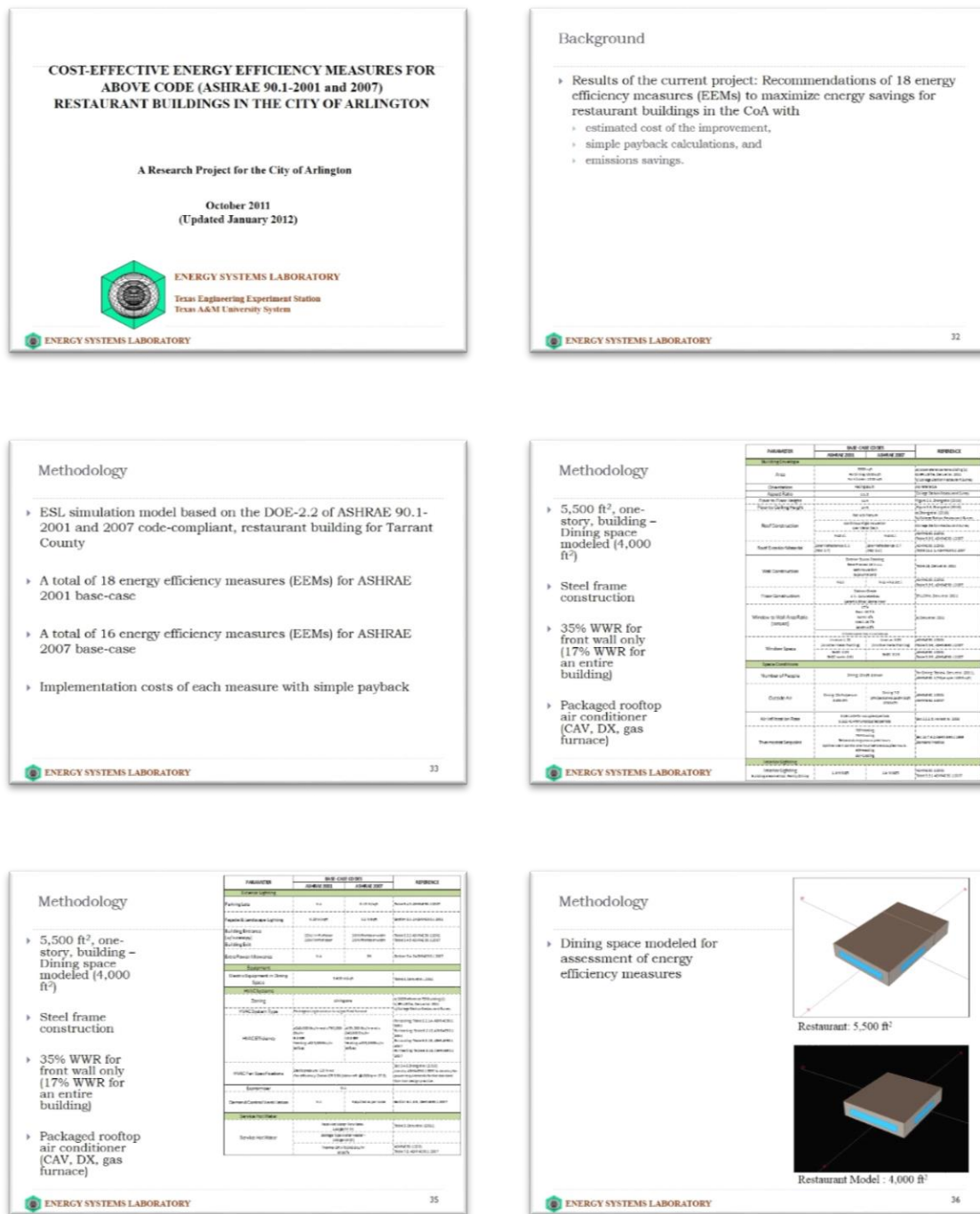


Figure 34: Presentation to the City of Arlington (Continued)





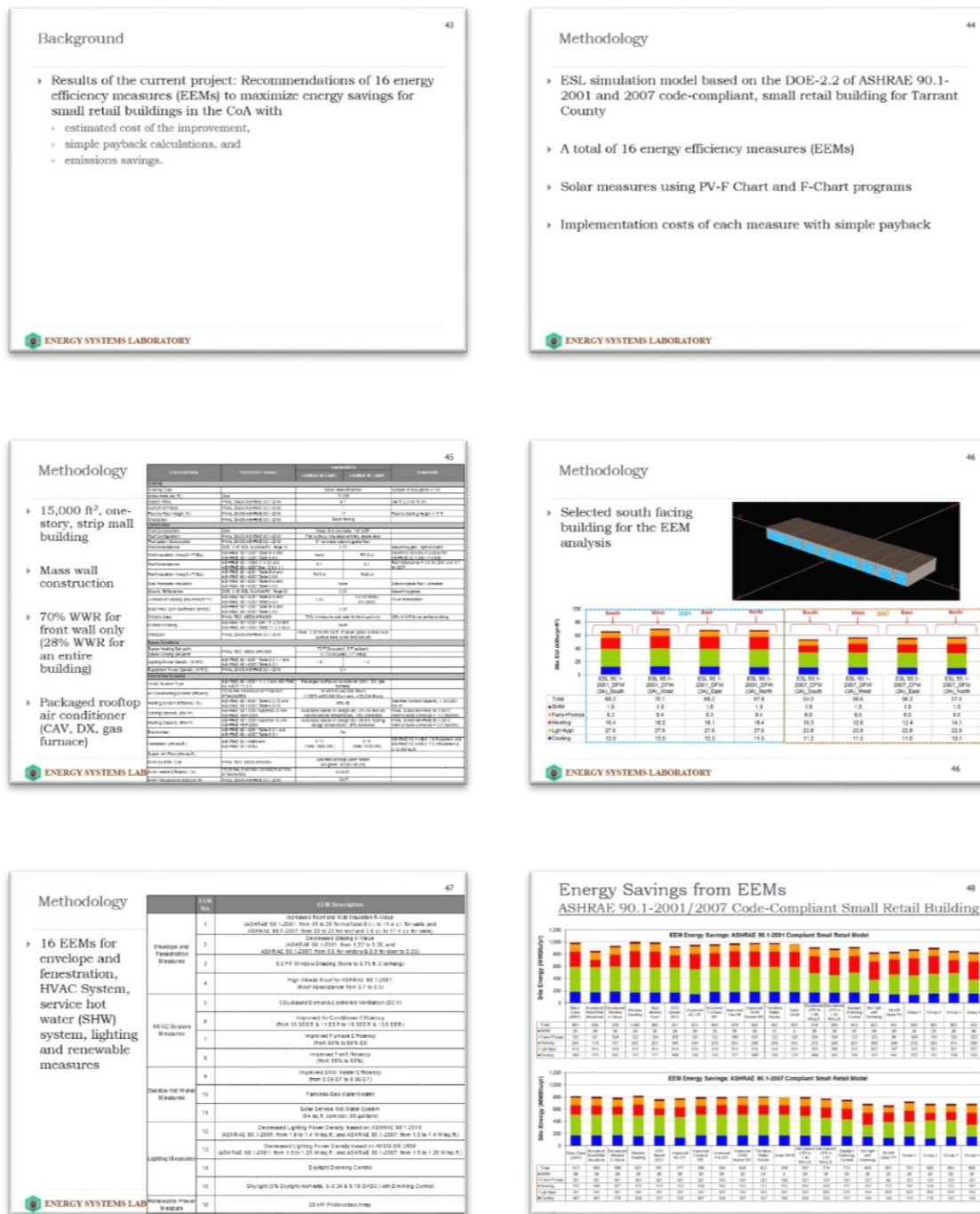


Figure 34: Presentation to the City of Arlington (Continued)

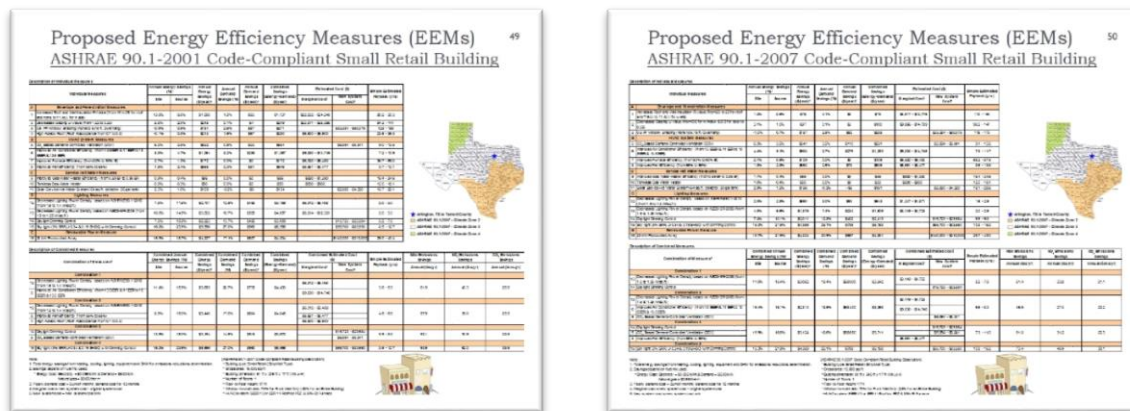


Figure 34: Presentation to the City of Arlington (Continued)



Presentations to BPI , February 2012

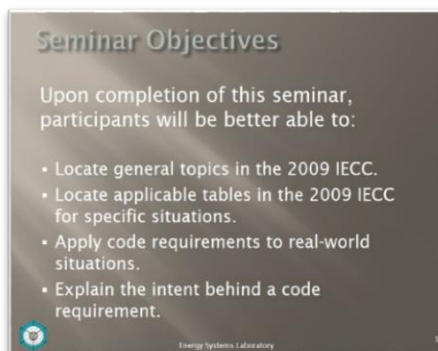
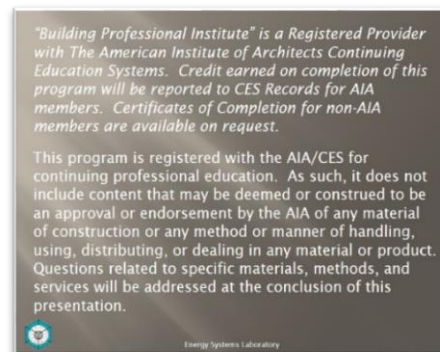
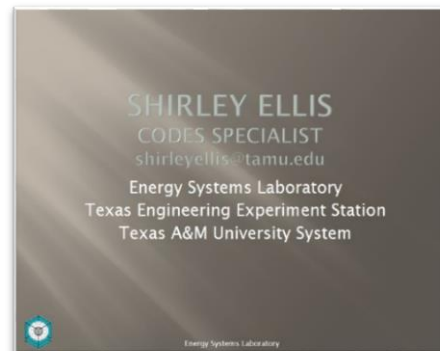
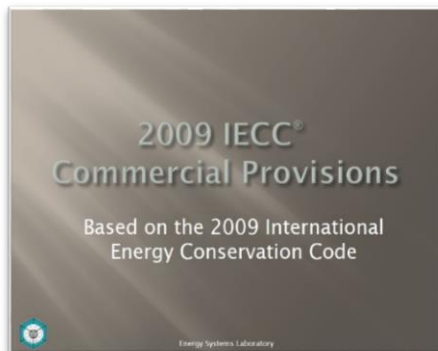


Figure 35: Presentations to BPI, February 2012 (continued)

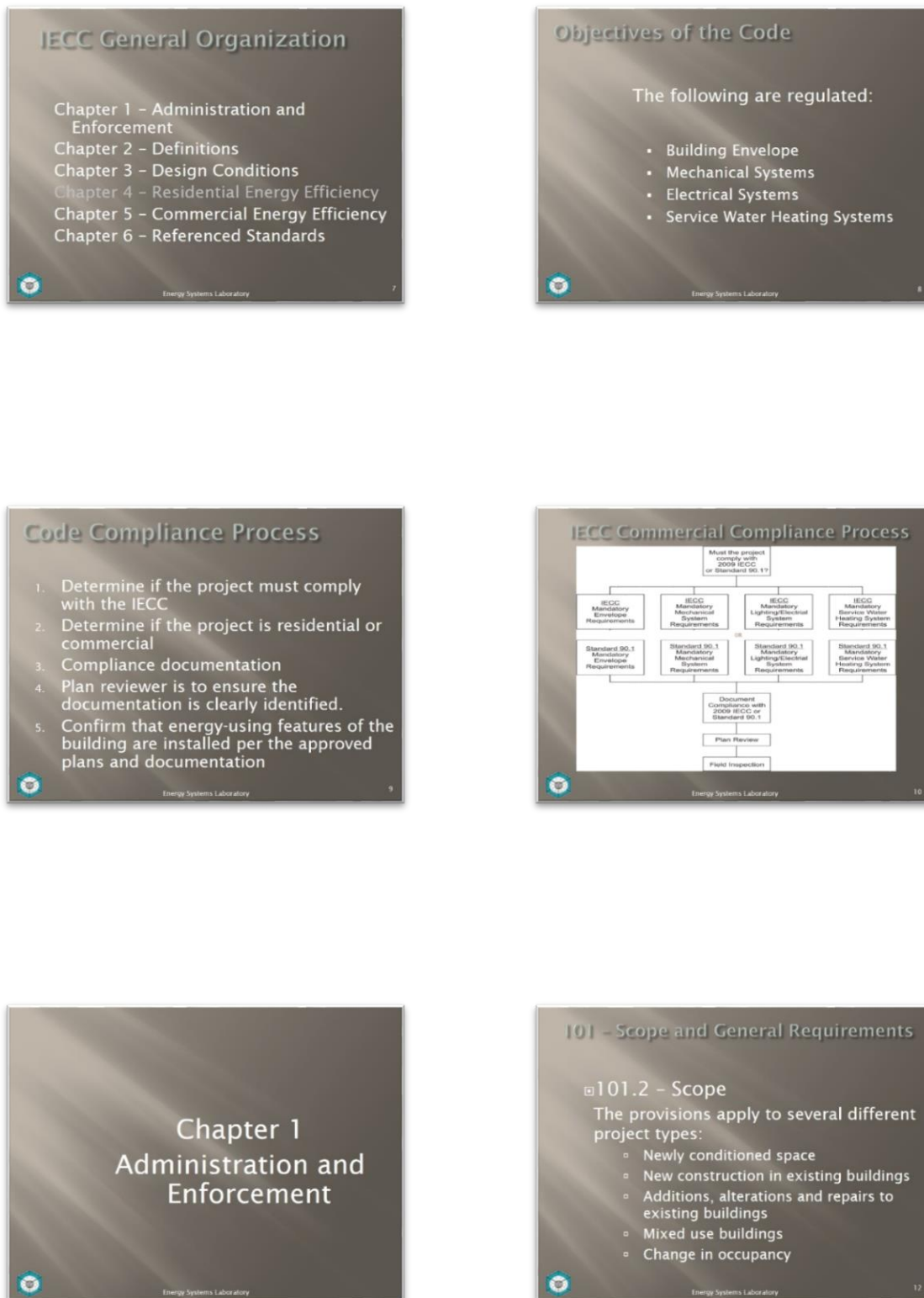


Figure 35: Presentations to BPI, February 2012 (continued)

**101 – Scope and General Requirements**

Newly Conditioned Space –  
New Buildings




New Construction - Hotel

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**101 – Scope and General Requirements**

Newly Conditioned Space –  
Previously Unconditioned




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**101 – Scope and General Requirements**

101.3 – Intent

Life safety, health and environmental requirements take precedence over energy provisions.




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**101 – Scope and General Requirements**

- 101.4 – Applicability
- 101.4.2 – Historic buildings



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**101 – Scope and General Requirements**

101.4.3 – Additions, alterations, renovations or repairs

- Where change increases energy use
- Applies to alteration as if it were new construction
- Exceptions
  - Storm windows over existing fenestration
  - Glass only replacements in existing frame
  - Existing ceiling, wall or floor cavities filled with insulation
  - Where existing roof, wall or floor cavity is not exposed

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**101 – Scope and General Requirements**

101.4.3 – Additions, alterations, renovations or repairs (cont.)

Exceptions

- Reroofing
- Replacement of existing doors
- Alterations that replace less than 50% of the luminaires in a space provided that there is no increase in installed lighting power
- Alterations that replace only the bulb and ballast with the existing luminaires

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Figure 35: Presentations to BPI, February 2012 (continued)

**101 – Scope and General Requirements**

**101.4.4 – Change in Occupancy**

An alteration that increases demand for fossil fuel or electrical energy onsite as a result of a change must comply with the code.

**101.4.5 – Change in space conditioning**

Any nonconditioned space that is altered to become conditioned space, must meet the requirements of the code.

**101.4.6 – Mixed Occupancy Mixed-use building**

**101.5.2 – Low Energy Buildings**

- Buildings designated as exempt include buildings that use less than 1 watt/ft<sup>2</sup> or 3.4 Btu/h ft<sup>2</sup> for space conditioning
- Buildings, or portions thereof, that are not conditioned are exempt from thermal envelope requirements

**102 Alternative Materials – Methods of Construction Design or Insulating Systems**

**102.1.1 – Above code program**

- Authority to approve “above code” program is vested in the code official
- Language does not guarantee alternative programs exceed the performance required by IECC
- Burden of proof to establish equivalency is on the applicant

**103 – Construction Documents**

**103.2 – Information on Construction Documents**


- Level of efficiency used to demonstrate compliance with the code must be clearly identified
- Complete set of building plans with efficiency requirements clearly labeled

Figure 35: Presentations to BPI, February 2012 (continued)

### 103 – Construction Documents

Information about the following systems should be included on the plans:

- Building envelope
- Mechanical system
- Lighting system
- Service water heating



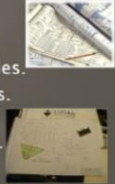

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### 103 – Construction Documents

Information can be presented in a number of ways:

- On the drawings.
- On sections and in schedules.
- Through notes and callouts.
- Through supplementary worksheets or calculations.


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### 103 – Construction Documents

#### 103.3 Examination of documents

- This section of the code covers the examination of documents and the various types of approvals that the code official will deal with on both new and existing buildings.



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### 104 - Inspections

The code states:

All construction is subject to inspection. Construction shall not be concealed without inspection approval. A final inspection is required before occupancy. A building shall be re-inspected when determined necessary by the code official.




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### 106 – Referenced Standards

#### 106.2 – Conflicting requirements

Code takes precedence when the requirements of the standard conflict with the requirements of the code




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### 106 – Referenced Standards

#### 106.2 – Other laws

The provisions of this code shall not be deemed to nullify any provisions of local, state, or federal law.



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Figure 35: Presentations to BPI, February 2012 (continued)

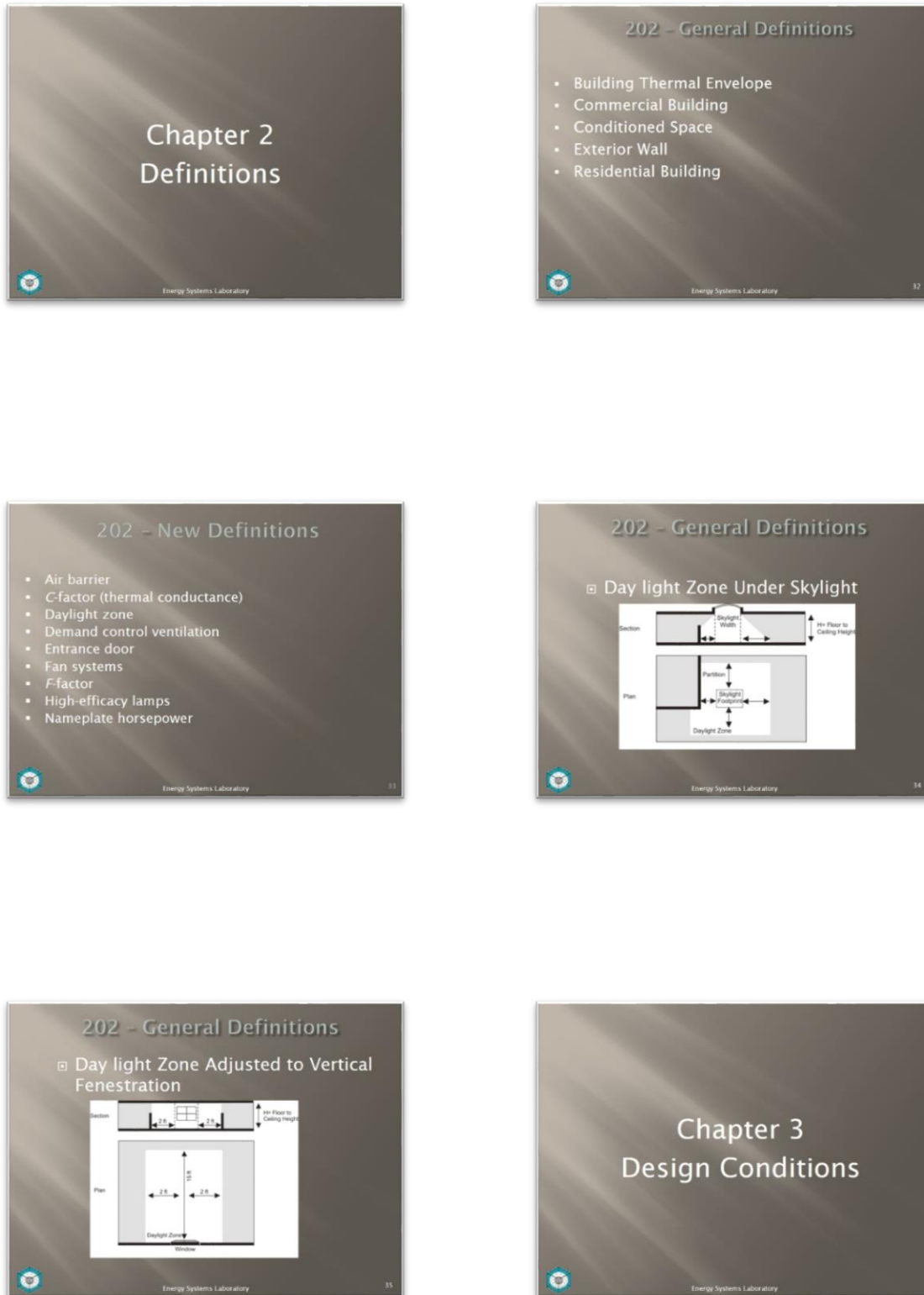
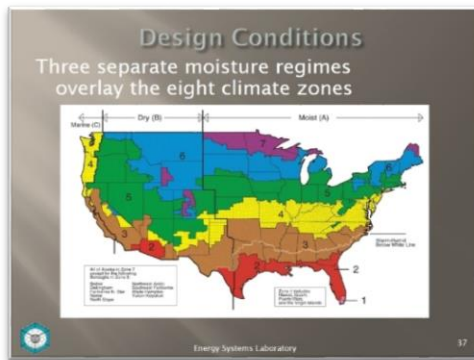


Figure 35: Presentations to BPI, February 2012 (continued)





### 303 - Materials, Systems, and Equipment

#### 303.1 - Identification

Requires materials to be labeled on site with the rated R-value

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### 303 - Materials, Systems, and Equipment

#### 303.1.3 - Fenestration product rating

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### 303 - Materials, Systems, and Equipment

#### Table 303.1.3(1) Default Window U-Factors

FRAME TYPE	SINGLE PANE		DOUBLE PANE		SKYLIGHT	
	Single	Double	Single	Double	Single	Double
Metal	1.20	0.80	2.00	1.30		
Metal with Thermal Break	1.10	0.65	1.90	1.10		
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05		
Glazed Block			0.60			

Fenestration maximum U-factor is the laboratory measurement of the overall thermal performance of a fenestration product

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### 303 - Materials, Systems, and Equipment

#### Table 303.1.3(2) Default Door U-Factors

DOOR TYPE	U-FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

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### 303 - Materials, Systems, and Equipment

#### Table 303.1.3(3) Default Glazed Fenestration SHGC

SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
Clear	Tinted	Clear	Tinted	
0.8	0.7	0.7	0.6	0.6

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Figure 35: Presentations to BPI, February 2012 (continued)

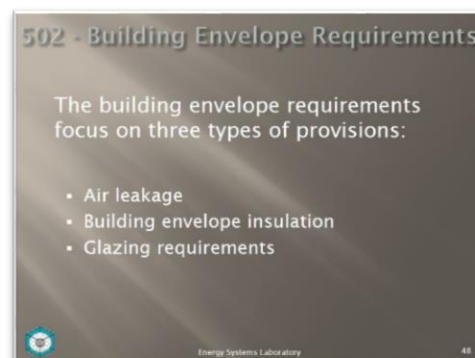
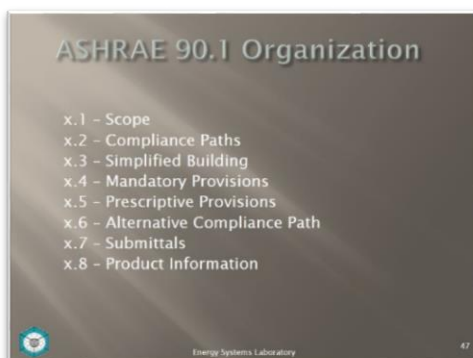
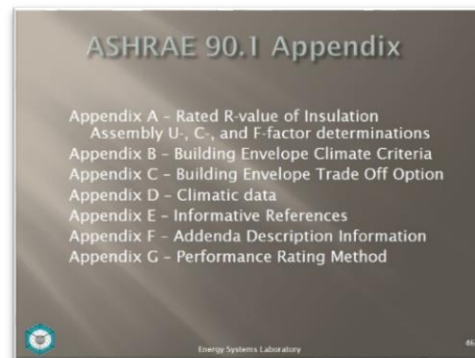
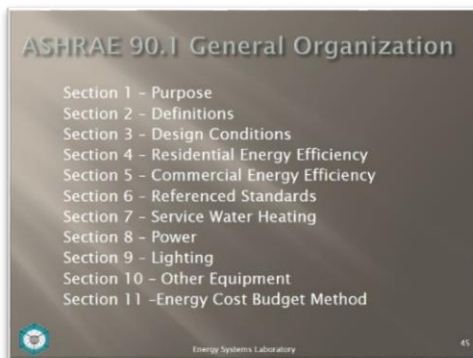
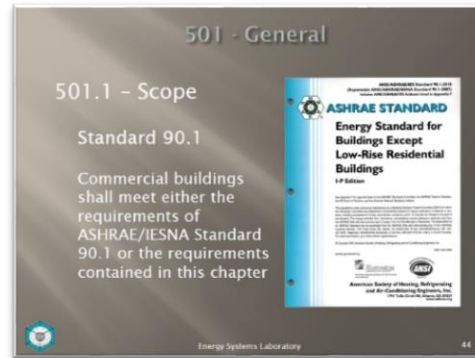
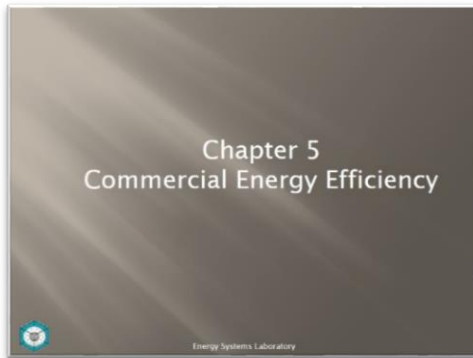


Figure 35: Presentations to BPI, February 2012 (continued)

## 502 - Building Envelope Requirements

### 502.2 – Specific insulation requirements (prescriptive)

Based on:

- Climate zone
- Window wall ratio and
- Construction assembly

All components must meet or exceed building envelope requirements

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## 502 - Building Envelope Requirements

### Table 502.2(1)- Building envelope requirements – Opaque assemblies

- Determine the climate zone
- Each assembly will have maximum *U*-factor and SHGC requirements and minimum *R*-value requirements
- R*-value requirements apply to the insulation only

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## 502 - Building Envelope Requirements

### TABLE 502.2(1) BUILDING ENVELOPE REQUIREMENTS - OPAQUE ASSEMBLIES

CLIMATE ZONE	1		2		3		4		5		6		7		8		
	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	
Roofs																	
Roofs - single slope	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Roofs - double slope	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Walls - exterior	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Walls - interior	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Floors																	
Floors - above grade	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Floors - below grade	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030

Energy Systems Laboratory 51

## 502 - Building Envelope Requirements

### TABLE 502.2(1) BUILDING ENVELOPE REQUIREMENTS - OPAQUE ASSEMBLIES

CLIMATE ZONE	1		2		3		4		5		6		7		8		
	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	Alt other	Group 9	
Roofs																	
Roofs - single slope	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Roofs - double slope	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Walls - exterior	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Walls - interior	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Floors																	
Floors - above grade	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Floors - below grade	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030

Energy Systems Laboratory 52

## 502 - Building Envelope Requirements

### Metal buildings - Roofs

Picture #1: Single Layer Draped Over Purlins

Picture #2: Thermal Blocks, Insulation Parallel to Purlins

Picture #3: Thermal Blocks, Insulation Parallel to Purlins

Picture #4: Thermal Blocks, Insulation Parallel to Purlins

Energy Systems Laboratory 53

## 502 - Building Envelope Requirements

### Metal buildings - Walls

Picture #4: Single Layer Faced Fiberglass

Picture #5: Thermal Block, Single Layer Faced Fiberglass

Energy Systems Laboratory 54

Figure 35: Presentations to BPI, February 2012 (continued)

## Building Envelope Requirements

### 502.2.7 - Opaque doors

All are required to meet the *U*-factor requirement for doors as specified in Table 502.2(1)

Includes overhead coiling and metal roll-up doors used for conditioned loading docks

Energy Systems Laboratory 55

## 502 - Building Envelope Requirements

### Table 502.3 – Building Envelope Requirements: Fenestration

The gross wall area includes:

- Above-grade walls
- Band and rim joists and spandrel area between floors
- Area of all doors and windows

Energy Systems Laboratory 56

## 502 - Building Envelope Requirements

### TABLE 502.3 BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE	1	2	3	4	5	6	7	8
<b>Vertical Fenestration (40% maximum of above-grade walls)</b>								
<i>E</i> -factor	1.20	0.75	0.60	0.40	0.35	0.35	0.35	0.35
<b>Framing material other than metal with or without metal reinforcement or cladding</b>								
<i>E</i> -factor	1.20	0.75	0.60	0.40	0.35	0.35	0.35	0.35
<b>Metal framing with or without thermal break</b>								
<i>E</i> -factor	1.20	0.75	0.60	0.40	0.35	0.35	0.35	0.35
<b>Exterior doors</b>								
<i>E</i> -factor	1.20	0.75	0.60	0.40	0.35	0.35	0.35	0.35
<b>All other <i>E</i>-factor*</b>								
<i>E</i> -factor	1.20	0.75	0.60	0.40	0.35	0.35	0.35	0.35
<b>Skylights (3% maximum)</b>								
<i>E</i> -factor	0.75	0.75	0.65	0.40	0.40	0.40	0.40	0.40
<i>U</i> -factor	0.35	0.35	0.35	0.40	0.40	0.40	0.40	0.40

NB: No requirement  
PP = Projection factor per Section 502.3.2  
\* All others include operable windows, fixed windows and overcooled doors.

Energy Systems Laboratory 57

## 502 - Building Envelope Requirements

### Skylights

- A skylight *U*-factor is based on the interior surface area of the entire skylight assembly, including glazing, sash, curbing and other framing elements

Energy Systems Laboratory 58

## 502 - Building Envelope Requirements

### 502.4 - Air Leakage (mandatory)

#### 502.4.1 - Window and door assemblies

#### 502.4.2 - Curtain wall, storefront glazing, and commercial entrance doors




Energy Systems Laboratory 59

## 502 - Building Envelope Requirements

### 502.4.3 - Sealing of the building envelope

- Exterior joints around windows and door frames
- Between wall sole plates, floors, and exterior wall panels
- Openings for plumbing, electricity, refrigerant and gas lines in exterior walls, floors, and roofs

Energy Systems Laboratory 60

Figure 35: Presentations to BPI, February 2012 (continued)



### 502 - Building Envelope Requirements

- Openings in the attic floor (such as where ceiling panels meet interior and exterior walls and masonry fireplaces)
- Service and access doors or hatches
- All similar openings in the building envelope

Sealing the building envelope reduces air infiltration in the building



Energy Systems Laboratory

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### 502 - Building Envelope Requirements

#### Sealing of the building envelope




Energy Systems Laboratory

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### 502.4.6 Loading Dock Weatherseals

- Equip cargo doors and loading dock doors with weatherseals
- Restrict infiltration




Energy Systems Laboratory

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### 502 - Building Envelope Requirements

#### 502.4.7 - Vestibules



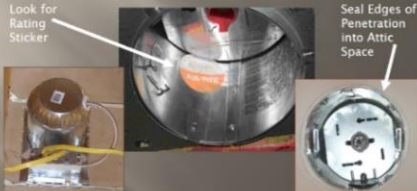

Energy Systems Laboratory

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### 502 - Building Envelope Requirements

#### 502.4.8 - Recessed luminaries

Look for Rating Sticker



Seal Edges of Penetration into Attic Space




Energy Systems Laboratory

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### 502 - Building Envelope Requirements

#### Moisture control (See IBC Sections 1405.3 and IRC Section R601.3)

- General requirements for control of moisture vapor entering the building have been relocated to the construction requirements of the IBC



Energy Systems Laboratory

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Figure 35: Presentations to BPI, February 2012 (continued)

### 503 - Building Mechanical Systems

- 503.2.1 - Calculation of heating and cooling loads
  - Designers must perform heating and cooling load calculations before sizing and selecting HVAC
  - HVAC systems must be sized based on the heating and cooling loads calculated in Section 503.2.1
  - When the cooling load is predominant the system must be sized to not exceed that load

Energy Systems Laboratory 66

### 503 - Building Mechanical Systems

Seven key elements to ensure HVAC system design is efficient:

- Equipment efficiency
- Proper equipment sizing and selection
- Distribution losses
- Transmission losses
- Controls
- Free-cooling
- Heat recovery

Energy Systems Laboratory 67

### 503 - Building Mechanical Systems

#### 503.2.2 - Equipment and system sizing

- "Shall not exceed the loads calculated"
- Equipment selected to meet space cooling loads must select capacity for heating based on smallest size within available equipment options
- Standby equipment to have controls and devices to operate automatically when primary equipment is not operating
- Multiple units with combined capacities that exceed design load shall have controls to sequence operation

Energy Systems Laboratory 68

### 503 - Building Mechanical Systems

#### 503.2.3 - HVAC equipment performance requirements

Equipment efficiency

Table 503.2.3(7) - Water Chilling Packages, Minimum Efficiency Requirements

Chiller Capacity (tons)	COP		EER		SEER	
	2010	2015	2010	2015	2010	2015
100	5.2	5.4	10.5	10.8	12.5	12.8
150	5.2	5.4	10.5	10.8	12.5	12.8
200	5.2	5.4	10.5	10.8	12.5	12.8
250	5.2	5.4	10.5	10.8	12.5	12.8
300	5.2	5.4	10.5	10.8	12.5	12.8
350	5.2	5.4	10.5	10.8	12.5	12.8
400	5.2	5.4	10.5	10.8	12.5	12.8
450	5.2	5.4	10.5	10.8	12.5	12.8
500	5.2	5.4	10.5	10.8	12.5	12.8
550	5.2	5.4	10.5	10.8	12.5	12.8
600	5.2	5.4	10.5	10.8	12.5	12.8
650	5.2	5.4	10.5	10.8	12.5	12.8
700	5.2	5.4	10.5	10.8	12.5	12.8
750	5.2	5.4	10.5	10.8	12.5	12.8
800	5.2	5.4	10.5	10.8	12.5	12.8
850	5.2	5.4	10.5	10.8	12.5	12.8
900	5.2	5.4	10.5	10.8	12.5	12.8
950	5.2	5.4	10.5	10.8	12.5	12.8
1000	5.2	5.4	10.5	10.8	12.5	12.8

Energy Systems Laboratory

### 503.2.4 - HVAC system controls

#### 503.2.4.1 - Thermostatic controls

Energy Systems Laboratory 71

### 503 - Building Mechanical Systems

#### 503.2.4.4 - Shutoff damper controls

Motorized dampers required on outdoor air supply and exhaust ducts

#### 503.2.4.5 - Snow melt system controls

Automatic controls

Pavement >50°F and no precipitation

Automatic or manual controls

Allow shutoff when outdoor temperature is >40°F

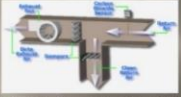
Energy Systems Laboratory 72

Figure 35: Presentations to BPI, February 2012 (continued)




**503 – Building Mechanical Systems**

503.2.5 – Ventilation  
503.2.5.1 – Demand control ventilation



503.2.6 – Energy Recovery Ventilation System



Energy Systems Laboratory 73

**503 – Building Mechanical Systems**

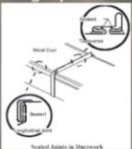
503.2.7 – Ducts and plenum insulation and sealing



Energy Systems Laboratory 74

**503 – Building Mechanical Systems**

503.2.7.1 – Duct construction  
503.2.7.1.1 – Low-pressure duct systems  
503.2.7.1.2 – Medium-pressure duct systems  
503.2.7.1.3 – High-pressure duct systems



Energy Systems Laboratory 75

**503 – Building Mechanical Systems**

503.2.8 – Piping insulation

- Piping serving as part of heating or cooling systems must be insulated according to Table 503.2.8

FLUID	NOMINAL PIPE DIAMETER	
	≤ 1.31"	> 1.31"
Steam	1½"	3"
Hot water	1½"	2"
Chilled water, brine or refrigerant	1½"	1½"

Energy Systems Laboratory 76

**503 – Building Mechanical Systems**

503.2.9 – HVAC system completion  
503.2.9.1 – Air system balancing  
503.2.9.2 – Hydronic system balancing

- Individual hydronic heating and cooling coils to be equipped with means for balancing and pressure test connectors




Energy Systems Laboratory 77

**503 – Building Mechanical Systems**

503.2.9.3 – Manuals

- Equipment capacity and required maintenance actions
- Equipment operation and maintenance manuals
- HVAC system control maintenance and calibration information, including schematics. Desired or field-determined setpoints shall be permanently recorded on drawings or at control devices
- A complete written narrative of how each system is intended to operate



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Figure 35: Presentations to BPI, February 2012 (continued)

**503 – Building Mechanical Systems**

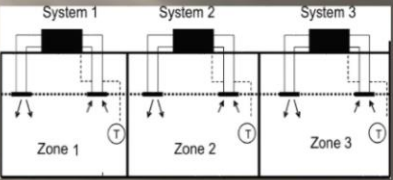
**503.3 – Simple HVAC systems and equipment**

Simple systems are served by unitary or packaged HVAC equipment, each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating system, where no cooling system is installed.

Energy Systems Laboratory 79

**503 – Building Mechanical Systems**

**503.3 – Simple HVAC systems and equipment**



Energy Systems Laboratory 80

**503 – Building Mechanical Systems**

**503.3.1 – Economizers**

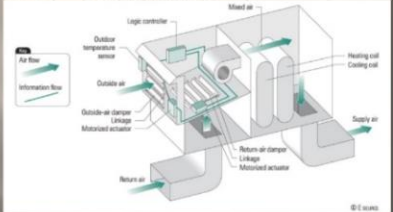
CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B, 2A, 7, 8	No requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B	Economizers on all cooling systems $\geq 54,000 \text{ Btu/hr}^a$

For SI: 1 British thermal unit per hour = 0.293 W.  
<sup>a</sup> The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater.

Energy Systems Laboratory 81

**503 – Building Mechanical Systems**

**503.3.1 – Economizers**



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**503 – Building Mechanical Systems**

**503.4 – Complex HVAC systems and equipment**

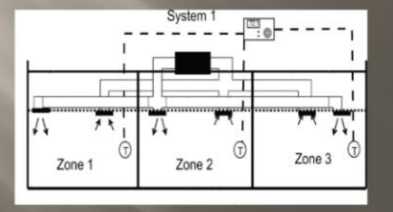
Includes:

- Systems serving multiple zones
- Hydronic steam heating and water chilling packages
- Variable air volume (VAV) systems
- Two-pipe changeover
- Four-pipe systems
- Hydronic (water loop) heat pump systems

Energy Systems Laboratory 83

**503 – Building Mechanical Systems**

**503.4 – Complex HVAC systems and equipment**



Energy Systems Laboratory 84

Figure 35: Presentations to BPI, February 2012 (continued)

### 503 - Building Mechanical Systems

#### 503.4.1 - Economizers

KEY:

- CWP Condenser Water Pump
- CHWP Chilled Water Pump
- CHWS Chilled Water Supply
- CHWR Chilled Water Return

Energy Systems Laboratory 85

### 503 - Building Mechanical Systems

#### 503.4.2 - Variable air volume (VAV) fan control

Individual VAV fan motors  $\geq 10$  Hp (7.5 kW)

- Driven by mechanical or electrical variable speed drive,

OR

- Have controls or devices resulting in a fan motor demand  $\leq 50\%$  of the design wattage at 50% of design airflow when static pressure set point =  $1/3$  of the total design static pressure

Energy Systems Laboratory 86

### Variable Air Volume

Energy Systems Laboratory

### 503 - Building Mechanical Systems

#### 503.4.3 - Hydronic systems controls

##### 503.4.3.1 - Three-pipe systems

##### 503.4.3.2 - Two-pipe changeover system

Outside air  $15^{\circ}\text{F}$  deadband  
Operate at least 4 hours  
Changeover temperature  $\leq 30^{\circ}\text{F}$

Energy Systems Laboratory 88

### 503 - Building Mechanical Systems

#### 503.4.3.3 - Hydronic (water loop) heat pump systems

- Heat pumps connected to a water loop with central heat rejection and heat addition
- Controls capable of providing  $20^{\circ}\text{F}$  dead band outside air temperature between initiation of heat rejection and heat addition

Energy Systems Laboratory 89

### 503 - Building Mechanical Systems

#### 503.4.3.4 - Part load controls

#### 503.4.3.5 - Pump isolation

- Chilled water plants with multiple chillers must have the capability to reduce flow automatically when a chiller shut down
- Boiler plants must have the capability to reduce flow automatically when a boiler is shut down

Energy Systems Laboratory 90

Figure 35: Presentations to BPI, February 2012 (continued)

### 503 – Building Mechanical Systems

#### 503.4.4 – Heat rejection equipment fan speed control

Fan Motors >7½ HP must have:

- Capability to operate fan at  $\leq 2/3$  of full speed or less, **and**
- Controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of heat rejection device
- Exception: Factory installed heat rejection devices within HVAC equipment meeting equipment efficiency requirements

Energy Systems Laboratory 91

### 503 – Building Mechanical Systems

#### 503.4.5 – Requirements for complex mechanical systems serving multiple zones

Supply air systems must be VAV systems. Controls are required to reduce primary air to each space before allowing:

- Reheating
- Recooling
- Mixing

Energy Systems Laboratory 92

### 503 – Building Mechanical Systems

#### 503.4.5 – Requirements for complex mechanical systems serving multiple zones

The primary air supply must be reduced by one of the following means before reheating, recooling, or mixing takes place:

- 30% of the maximum supply air flow to each zone
- 300 cfm (142 L/s) where maximum flow rate is less than 10% of total fan system supply airflow rate
- Minimum ventilation requirements of the International Mechanical Code\* (IMC)

Energy Systems Laboratory 93

### 503 – Building Mechanical Systems

#### 503.4.6 – Heat recovery for service water heating

Condenser heat recovery required for heating or reheating service hot water where

- Facility operates 24 hours a day, **and**
- Total installed heat capacity of water cooled systems >6,000,000 Btu/hr of heat rejection, **and**
- Design service water heating load exceeds 1,000,000 Btu/h

Capacity to provide

- Sixty percent of the peak heat rejection load at design conditions, **or**
- Preheating required to raise the peak service hot water to 85°F

Energy Systems Laboratory 94

### 504 – Service Water Heating

#### 504.4 – Heat traps





Manufactured Heat Trap Device



Energy Systems Laboratory 95

### 504.5 – Pipe Insulation

- Circulating systems
  - 1" of insulation on piping
  - R-3.5/inch minimum
- Noncirculating systems
  - without integral heat traps
    - 1/2" for first 8 feet
    - R-3.5/inch minimum

Energy Systems Laboratory

Figure 35: Presentations to BPI, February 2012 (continued)



### 504.6 - Hot Water System Controls

**Automatic circulating hot water systems and heat trace**  
Turned off automatically or manually when the system is not in operation



Energy Systems Laboratory

### 504.7 - Pools

**Pool Heaters**

- Readily accessible On/Off switch on heater
- Natural gas heaters shall not have continuously burning pilot lights

**Time switches**

- All - Heated and Unheated
  - Time clocks for circulation pumps according to a preset schedule
  - Exception
    - Where 24 hour operation is required for public health standards
    - Where pumps are required to operate solar and waste-heat recovery pool heating systems

Energy Systems Laboratory

### Pool Covers

- Pool Covers**
  - Required on heated pools
    - 90°F requires R-12 minimum
  - Vapor retardant, on or at the pool surface
  - Exception
    - 60% of the energy for heating is from site-recovered or site-solar energy



Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

Interior lighting plays a major role in the energy usage of a commercial building. An increased lighting load increases the capacity requirements for the cooling system.

**The lighting requirements focus on these elements:**

- Controls
- Light reduction methods
- Tandem wiring
- Interior and exterior lighting power

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

The lighting requirements apply to the design of:


- New lighting systems in conditioned or unconditioned spaces
- Altered components/systems as part of alteration
- Altered system that increases the lighting load resulting from change of occupancy
- Exterior lighting systems

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

#### 505.2 - Lighting controls

- 505.2.1 - Interior lighting controls
- 505.2.2 - Additional controls
  - 505.2.2.1 - Light reduction controls
    - Light reduction controls differ from switching controls in that instead of turning the lights off, these controls lower the light output. They can be either dimming or switching depending on the light source you are controlling and the area being controlled



Energy Systems Laboratory

Figure 35: Presentations to BPI, February 2012 (continued)

### 505 - Electrical Power and Lighting Systems

#### 505.2.2.2 - Automatic lighting shutoff

Automatic Lighting Control

Occupancy Sensor

Open Bay Office

Office

Conference Room

Lobby

Restrooms

For SI: 1 foot = 304.8 mm.

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

#### 505.2.2.2.1 - Occupant override

If an automatic time switch control is installed, it must have an occupant override, be readily accessible, and have the following:

- Be in view of the lights
- Manually operated
- Two-hour override limit
- Controls area less than 5,000 square feet
- Holiday scheduling feature

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

#### 505.2.2.3 - Daylight zone control

Daylight zones shall be provided with individual controls that control the lights independent of general area lighting

- Exception
  - Daylight spaces enclosed by walls or ceiling height partitions, and
  - Containing two or fewer light fixtures

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

#### 505.2.3 - Sleeping units

Standard Room

Suite

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

#### 505.2.4 - Exterior lighting controls

- Must be controlled so they are automatically shut off during daylight hours
- Seven day/seasonal daylight program
- Minimum 4-hour battery backup

Energy Systems Laboratory

### 505 - Electrical Power and Lighting Systems

#### 505.3 - Tandem wiring

When Closer than 10 ft.  
(Measured center-to-center of fixtures)

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Figure 35: Presentations to BPI, February 2012 (continued)



## 505 - Electrical Power and Lighting Systems

### 505.4 - Exit signs



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## 505 - Electrical Power and Lighting Systems

### 505.5 - Interior lighting power requirement

- 505.5.1 - Total connected interior lighting power
  - Exceptions
- 505.5.1.1 Screw lamp holders
- 505.5.1.2 Low-voltage lighting
- 505.5.1.3 Other luminaires
- 505.5.1.4 Line-voltage lighting track and plug-in busway

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Building Area Type <sup>a</sup>	(W/m <sup>2</sup> )
Air-conditioned Facility	0.9
Automotive Center	1.2
Civic House	1.2
Clothing, Dry Cleaning/Laundry	1.2
Cooking, Kitchen/Pan. Food	1.4
Cinema, Theatre	1.0
Convenience	1.0
Department Store	1.0
Dispersed	1.1
Healthcare - office	1.0
Hospital	1.2
Hotel	1.0
Library	1.2
Manufacturing Facility	1.1
Mixed	1.0
Motion Picture Theatre	1.2
Multitenant	0.7
Museum	1.1
Office	1.0
Outdoors	0.5
Performing Arts Theatre	1.0
Post Office	1.0
Public Office	1.1
Religious Building	1.2
Retail	1.2
Suburban University	1.2
Supermarket	1.1
Transit Bldg	1.1

(continued)

Building Area Type <sup>a</sup>	(W/m <sup>2</sup> )
Transportation	1.0
Warehouse	0.8
Workshop	1.4

<sup>a</sup> For 10' x 10' x 10' ft room, 1 watt per square foot = 10.76 W/m<sup>2</sup>.

<sup>b</sup> In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.

<sup>c</sup> When lighting equipment is specified to be installed in lighting specific enclosures or fixtures, the lighting equipment specified for general lighting and is omitted or omitted in cases where the lighting equipment is specified specifically for merchandise, or additional lighting power is determined below shall be added to the interior lighting power determined in accordance with this table.

Calculate the additional lighting power as follows:

Additional Interior Lighting Power Allowance = 1000 watts x (Retail Area 1 + 0.5 W/m<sup>2</sup>) + (Retail Area 2 + 0.5 W/m<sup>2</sup>) + (Retail Area 3 + 0.5 W/m<sup>2</sup>) + (Retail Area 4 + 0.5 W/m<sup>2</sup>)

Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = The floor area used for the sale of vehicles, sporting goods, and small electronics.

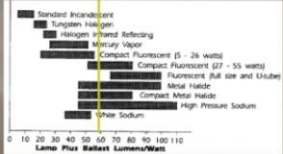
Retail Area 3 = The floor area used for the sale of books, clothing, cosmetics and jewelry.

Retail Area 4 = The floor area used for the sale of jewelry, crystal and glass.

Exception: Other non-merchandise categories are permitted to be included in Retail Area 2 through 4, provided that the lighting power is determined for the additional lighting power based on visual inspection, analysis, or other data display is approved by the authority having jurisdiction.

## 505 - Electrical Power and Lighting Systems

### 505.6.1 - Exterior building and grounds lighting



Energy Systems Laboratory 112

## 505 - Electrical Power and Lighting Systems

### 505.6.2 - Exterior building lighting power Exceptions

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

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Lighting Zone	Area Type	Power Density (W/m <sup>2</sup> )	Power Density (W/m <sup>2</sup> )	Power Density (W/m <sup>2</sup> )	Power Density (W/m <sup>2</sup> )
Zone 1	Open Space	0.5	0.5	0.5	0.5
	Pathways	1.0	1.0	1.0	1.0
	Driveways	1.0	1.0	1.0	1.0
	Other	1.0	1.0	1.0	1.0
Zone 2	Open Space	0.5	0.5	0.5	0.5
	Pathways	1.0	1.0	1.0	1.0
	Driveways	1.0	1.0	1.0	1.0
	Other	1.0	1.0	1.0	1.0
Zone 3	Open Space	0.5	0.5	0.5	0.5
	Pathways	1.0	1.0	1.0	1.0
	Driveways	1.0	1.0	1.0	1.0
	Other	1.0	1.0	1.0	1.0
Zone 4	Open Space	0.5	0.5	0.5	0.5
	Pathways	1.0	1.0	1.0	1.0
	Driveways	1.0	1.0	1.0	1.0
	Other	1.0	1.0	1.0	1.0


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Figure 35: Presentations to BPI, February 2012 (continued)

## 505 – Electrical Power and Lighting Systems

### 505.7 – Electrical energy consumption

In buildings having individual dwelling units, provisions shall be made to determine the electrical consumed by each tenant by separately metering individual dwelling units





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## 506 – Total Building Performance

### 506.1 – General

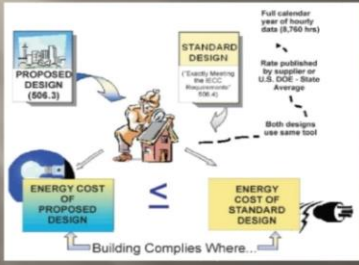

The Total Building Performance Method allows trade-offs among the building envelope, mechanical systems, and lighting systems in commercial buildings.

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## 506 – Total Building Performance

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## 506 – Total Building Performance

### 506.4 – Documentation

The documentation that is required to support the analysis must provide the following information:



- Annual energy use and cost
- List of building features
- Output files showing energy use totals
- Energy use by source and end use
- Total hours that the space conditioning loads were not met
- Software error messages or warnings
- Written explanations of any error messages or warnings



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## Questions and Answers

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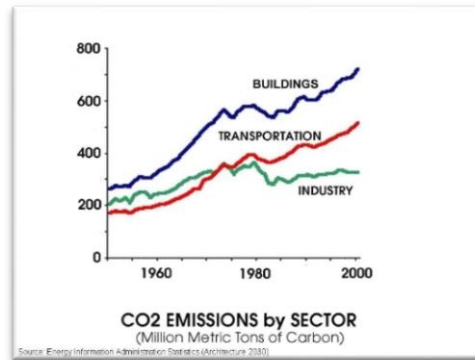
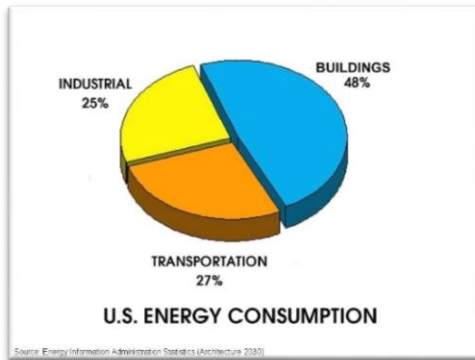


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Figure 35: Presentations to BPI, February 2012 (continued)



Figure 35: Presentations to BPI, February 2012 (continued)



### CODE COMPLIANCE PROCESS

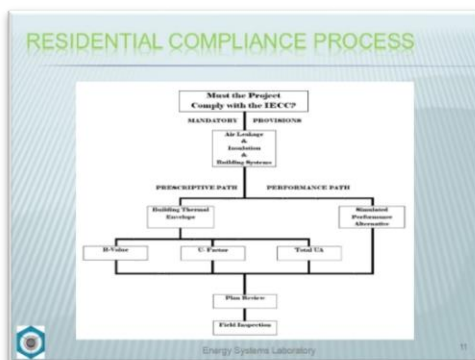
1. Determine if the project must comply with the IECC
2. Determine if the project is residential or commercial
3. Compliance documentation
4. Plan reviewer is to ensure the documentation is clearly identified
5. Confirm that energy-using features of the building are installed per the approved plans and documentation

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### THE FOLLOWING ARE REGULATED:

- Building Envelope
- Mechanical Systems
- Electrical Systems
- Service Water Heating Systems

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### ORGANIZATION

Chapter 1 –	Administration and Enforcement
Chapter 2 –	Definitions
Chapter 3 –	Design Conditions
Chapter 4 –	Residential Energy Efficiency
Chapter 5 –	Commercial Energy Efficiency
Chapter 6 –	Referenced Standards

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Figure 35: Presentations to BPI, February 2012 (continued)



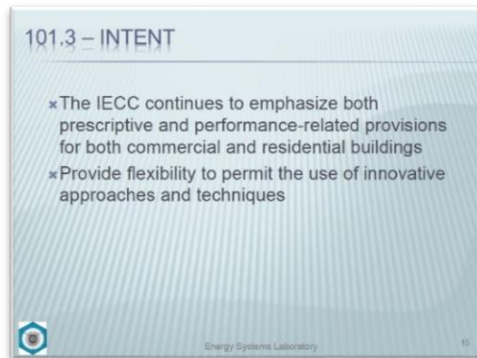
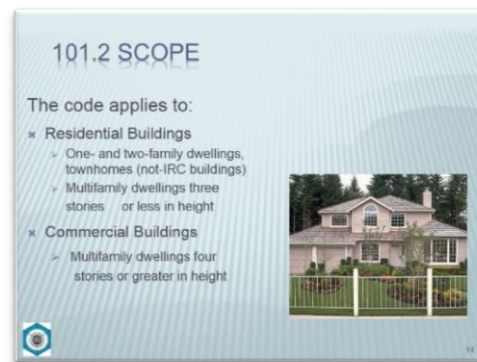
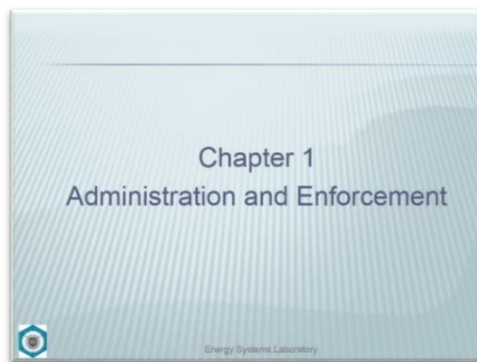


Figure 35: Presentations to BPI, February 2012 (continued)



Figure 35: Presentations to BPI, February 2012 (continued)





Figure 35: Presentations to BPI, February 2012 (continued)



Figure 35: Presentations to BPI, February 2012 (continued)

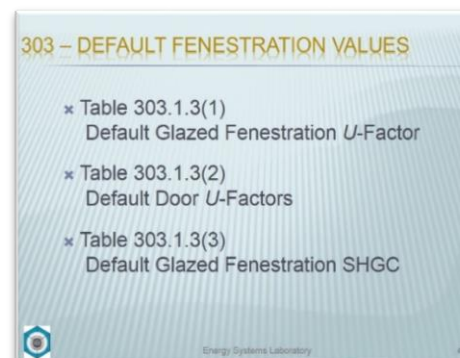
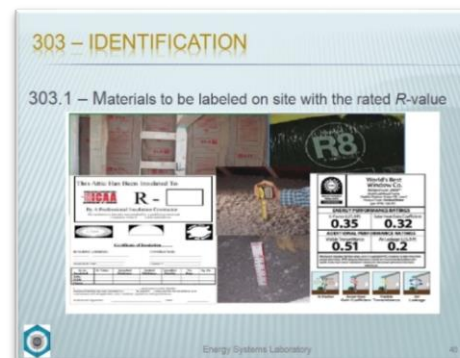
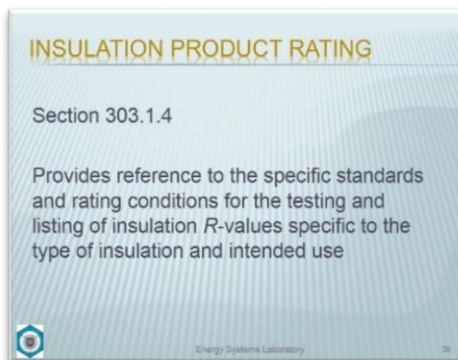
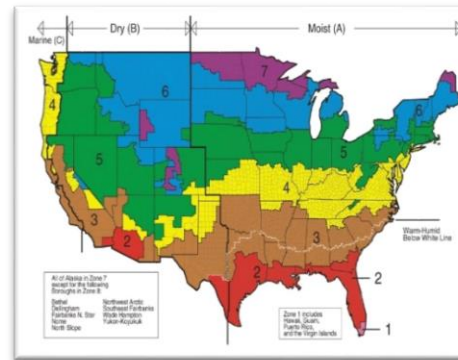
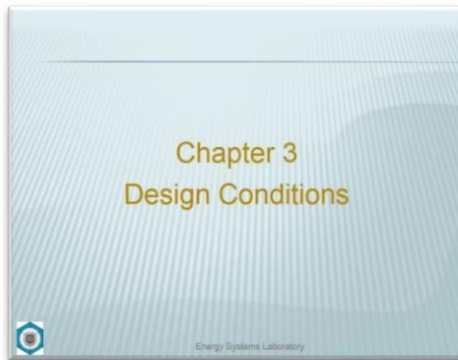


Figure 35: Presentations to BPI, February 2012 (continued)

**TABLE 303.1.3(1) GLAZED FENESTRATION VALUES**

**TABLE 303.1.3(1)  
DEFAULT GLAZED FENESTRATION U-FACTOR**

FRAME TYPE	SINGLE PANE		DOUBLE PANE		SKYLIGHT	
	Single	Double	Single	Double	Single	Double
Metal	1.20	0.80	2.00	1.30		
Metal with Thermal Break	1.10	0.65	1.90	1.10		
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05		
Glazed Block			0.60			

**TABLE 303.1.3(2) DOOR VALUES**

**TABLE 303.1.3(2)  
DEFAULT DOOR U-FACTORS**

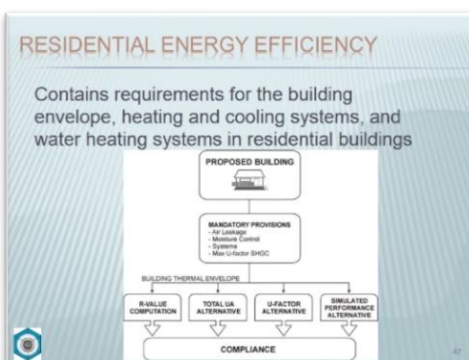
DOOR TYPE	U-FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

**TABLE 303.1.3(3) – SOLAR HEAT GAIN COEFFICIENT**

**TABLE 303.1.3(3)  
DEFAULT GLAZED FENESTRATION SHGC**

SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
Clear	Tinted	Clear	Tinted	
0.8	0.7	0.7	0.6	0.6

## Chapter 4 Residential Energy Efficiency



## COMPLIANCE METHODS

402.1.2 – Compliance by *R*-value computation  
Table 402.1.1 – Insulation and Fenestration Requirements by Component

402.1.3 – *U*-factor alternative  
Table 402.1.3 – Equivalent *U*-Factors

Figure 35: Presentations to BPI, February 2012 (continued)



**TABLE 402.1.1**  
**INSULATION AND PENETRATION REQUIREMENTS BY COMPONENT<sup>a</sup>**

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	GLAZED FENESTRATION U-FACTOR	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE	FLOOR R-VALUE	BASEMENT <sup>b</sup> WALL R-VALUE	SLAB <sup>c</sup> R-VALUE	CEILING SPACE WALL R-VALUE
1	1.2	0.75	0.30	30	13	3/8	13	0	0
2	0.85	0.75	0.30	30	13	4/8	13	0	0
3	0.50	0.65	0.30	30	13	5/8	19	5/12 <sup>d</sup>	0
4 except Marine	0.35	0.60	NR	38	13	5/10	19	10/13	10, 2 ft
5 and Marine 4	0.35	0.60	NR	38	20 or 15a <sup>e</sup>	15/17	30 <sup>f</sup>	10/13	10, 2 ft
6	0.35	0.60	NR	49	20 or 15a <sup>e</sup>	15/19	30 <sup>f</sup>	15/19	10, 4 ft
7 and 8	0.35	0.60	NR	49	21	19/21	38 <sup>f</sup>	15/19	10, 4 ft

For 10: 1 foot = 304.8 mm.  
 a. R-value requirements, U-factors and SHGC requirements. R-values are based on a nominal 2 x 4 framing cavity such that the R-value is reduced by 0.1 or more shall be marked with the compound R-value in addition to the full thickness R-value.  
 b. The basement U-factor values exclude skylights. The SHGC values apply to all glazed fenestrations.  
 c. "5/12" means R-13 continuous insulation sheathing on the interior or exterior of the basement wall. "15/19" shall be permitted to be used with R-13 cavity insulation on the exterior of the basement wall plus R-5 continuous insulation sheathing on the interior or exterior of the house. "19/21" means R-19 continuous insulation sheathing on the interior or exterior of the house or R-13 cavity insulation on the exterior of the basement wall.  
 d. R-5 shall be added to the required slab edge R-value for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Zones 1 through 3 for heated slabs.  
 e. There are no SHGC requirements in the Marine Zone.  
 f. Basement wall insulation is not required in warm humid locations as defined by Figure 301.1 and Table 301.1.  
 g. On insulation sufficient to fill the framing cavity R-19 minimum.  
 h. "15a" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25 percent or less of the exterior, insulated sheathing is not required when structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulation sheathing of at least R-5.  
 i. The nominal R-value applies when more than half the insulation is on the interior of the mass wall.  
 j. For required mass foundation complying with Section 602.1.2.2 of the International Residential Code or Section 1608.1.2 of the International Building Code, the minimum U-factor shall be 0.17 in Zone 2 and 0.07 in Zone 3.

**TABLE 402.1.3**  
**EQUIVALENT U-FACTOR<sup>a</sup>**

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR <sup>b</sup>	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR <sup>c</sup>	CEILING SPACE WALL U-FACTOR <sup>d</sup>
1	1.20	0.75	0.015	0.082	0.197	0.064	0.380	0.477
2	0.85	0.75	0.015	0.082	0.165	0.064	0.380	0.477
3	0.50	0.65	0.015	0.082	0.141	0.047	0.097 <sup>e</sup>	0.136
4 except Marine	0.35	0.60	0.030	0.082	0.141	0.047	0.059	0.085
5 and Marine 4	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.085
6	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.085
7 and 8	0.35	0.60	0.026	0.057	0.057	0.028	0.050	0.085

a. Nonfenestration U-factors shall be obtained from measurement, calculation or an approved source.  
 b. When more than half the insulation is on the interior, the mass wall U-factor shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.09 in Zone 4 except Marine, and the same as the frame wall U-factor in Marine Zone 4 and Zones 5 through 8.  
 c. Basement wall U-factor of 0.380 in warm-humid locations as defined by Figure 301.1 and Table 301.2.  
 d. Foundation U-factor requirements shown in Table 402.1.3 include wall construction and interior air films but exclude wall conductivity and exterior air films.  
 e. U-factors for determining code compliance in accordance with Section 402.1.4 (total UA alternative) of Section 405 (Streamlined Performance Alternative) shall be modified to include wall conductivity and exterior air films.

## DETERMINING COMPLIANCE

An assembly *U*-factor must be calculated for each applicable assembly type proposed for the project.

The ASHRAE *Handbook of Fundamentals* is an excellent source of information on how to calculate an assembly *U*-factor.



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## CALCULATING ASSEMBLY U-FACTORS

- ✕ The calculation must include the effects of framing
- ✕ An *R*-value must be determined for each different material in the assembly
- ✕ The *R*-values are then totaled to determine the total *R*-value through each thermal path of the assembly
- ✕ The total *R*-values are then converted to *U*-factors by taking the reciprocal of the *R*-value
- ✕ An area-weighted average *U*-factor is calculated for the wall system that takes into account the effects of framing



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## SAMPLE CALCULATION—WALLS

$$U_{OW} = \frac{(U_{w1} \times A_{w1}) + (U_{w2} \times A_{w2}) + \dots}{A_{w1} + A_{w2} + \dots}$$

Where

- $U_{w1}$  = *U*-factor of opaque wall number 1
- $A_{w1}$  = Area of opaque wall number 1
- $U_{w2}$  = *U*-factor of opaque wall number 2
- $A_{w2}$  = Area of opaque wall number 2



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## 402.1.4 – TOTAL UA ALTERNATIVE

- The building envelope design is permitted to deviate from *R*-values or *U*-factors in Tables 402.1.1 or 402.1.3, respectively, provided the total thermal transmittance (*UA*) is the same or less as the very same building envelope geometry designed to code



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Figure 35: Presentations to BPI, February 2012 (continued)



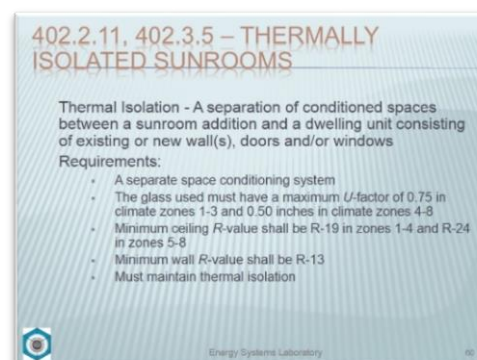
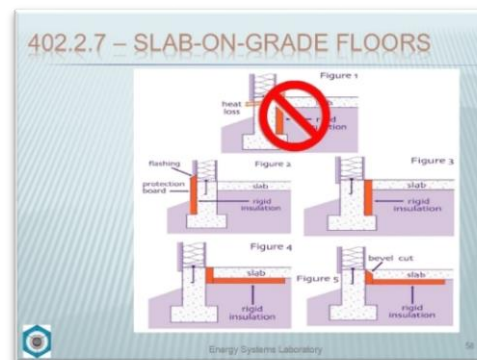
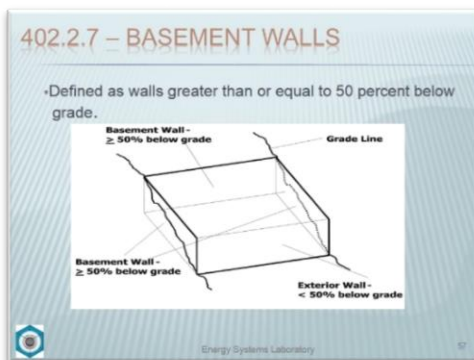
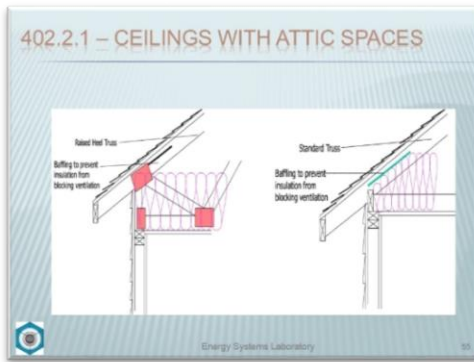
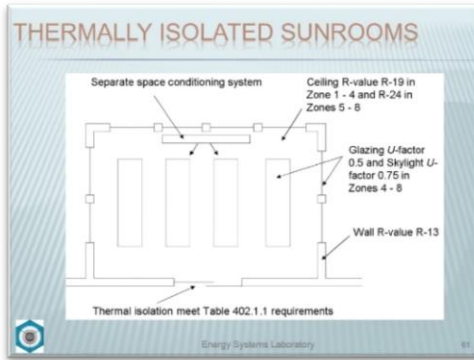


Figure 35: Presentations to BPI, February 2012 (continued)



## 402.3 – FENESTRATION

### 402.3.1 U-factor

- Area weighted average U-factors and SHGCs may be used to comply with Table 402.1.1.
  - Up to 15 ft<sup>2</sup> of glazed fenestration per dwelling unit can be exempted from U-factor and SHGC requirements.
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### 402.3.2 – GLAZED FENESTRATION SHGC

The SHGC measures how well a window or translucent product blocks heat caused by sunlight. SHGC is expressed as a number between 0 and 1. The lower the number, the lower the amount of heat that passes into the building through the glazing.

Fenestration must be rated using NFRC 200 or a default SHGC value is to be assigned from Table 303.1.3(3).

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## EXEMPTION

- × 402.3.3 Glazed fenestration SHGC & 402.3.3 Glazed fenestration exemption
    - Up to 15 square feet (1.4 m<sup>2</sup>) of glazed fenestration per dwelling unit can be exempted from U-factor and SHGC requirements
  - × 402.3.4 Opaque door
    - One hinged opaque door up to 24 square feet (2.22m<sup>2</sup>) is also exempt
  - × 402.3.6 Replacement fenestration
    - Replacement windows and skylights must comply with the fenestration U-factor requirements of Table 402.1.1.
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## 402.4, 402.5, 402.6, 403 – MANDATORY REQUIREMENTS

### 402.4 – Air Leakage (mandatory)

#### 402.4.1 – Building thermal envelope

#### 402.4.2 – Air Sealing and Insulation

- Building envelope air tightness and insulation shall be demonstrated in one of two ways.
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### 402.4.2.1 TESTING OPTION

Requires testing at specific air changes per hour at a specific air pressure

There are seven requirements

1. Exterior windows and doors, fireplaces and stove doors closed, but not sealed
  2. Dampers shall be closed but not sealed
  3. Interior doors open
  4. Exterior openings for continuous ventilation systems and heat recovery ventilators closed and sealed
  5. Heating and cooling systems turned off
  6. HVAC shall not be sealed
  7. Supply and return registers shall not be sealed.
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Figure 35: Presentations to BPI, February 2012 (continued)

### BLOWER DOOR TESTING

Calculate Leakage from House Pressure and AirFlow Rate

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### 402.4.2.2 VISUAL INSPECTION OPTION

COMPONENT	TEST METHOD	TEST RESULTS
Air barrier and thermal barrier	Visual inspection of exterior walls, roof, and foundation for cracks, gaps, and other defects.	Visual inspection of exterior walls, roof, and foundation for cracks, gaps, and other defects.
Windows and doors	Visual inspection of windows and doors for cracks, gaps, and other defects.	Visual inspection of windows and doors for cracks, gaps, and other defects.
Roofs	Visual inspection of roofs for cracks, gaps, and other defects.	Visual inspection of roofs for cracks, gaps, and other defects.
Foundations	Visual inspection of foundations for cracks, gaps, and other defects.	Visual inspection of foundations for cracks, gaps, and other defects.
Attic	Visual inspection of attic for cracks, gaps, and other defects.	Visual inspection of attic for cracks, gaps, and other defects.
Basement	Visual inspection of basement for cracks, gaps, and other defects.	Visual inspection of basement for cracks, gaps, and other defects.
Garage	Visual inspection of garage for cracks, gaps, and other defects.	Visual inspection of garage for cracks, gaps, and other defects.
Driveway	Visual inspection of driveway for cracks, gaps, and other defects.	Visual inspection of driveway for cracks, gaps, and other defects.
Landscaping	Visual inspection of landscaping for cracks, gaps, and other defects.	Visual inspection of landscaping for cracks, gaps, and other defects.
Other	Visual inspection of other areas for cracks, gaps, and other defects.	Visual inspection of other areas for cracks, gaps, and other defects.

→ The Building Official may require an approved party independent from the installer of insulation to inspect the air barriers and insulation.

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### 402.4.3 – FIREPLACES

New wood-burning fireplaces shall have gasketed doors and outdoor combustion air

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### 402.4.4 – FENESTRATION AIR LEAKAGE

Sets the testing requirements for air leakage rates in windows, skylights and sliding glass and swinging doors

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### 402.4.5 – RECESSED LIGHTING

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### 402.5 – MAXIMUM FENESTRATION U-FACTOR AND SHGC (MANDATORY)

Limits the maximum area-weighted U-factor and SHGC that can be traded-off among opaque envelope components for the purpose of envelope compliance

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Figure 35: Presentations to BPI, February 2012 (continued)



### 403 – BUILDING SYSTEMS

The building systems addressed consist of a heating and/or cooling system, a distribution system and temperature controls.

Labels in diagram: Heating and Cooling Efficiency, A/C UNIT, FURNACE, Ductwork, Duct Installation and Insulation, Temperature & Humidity Controls, Pipe Insulation.

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### THERMOSTAT AND CONTROLS

- × 403.1.1 – Programmable Thermostat
- × 403.1.2 – Heat pump supplementary heat (Mandatory)

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### 403.2 – DUCTS

- × 403.2.1 – Insulation
  - + Supply ducts in attics shall be R-8 min
  - + All other ducts shall be R-6 min
  - + Exception
    - × Ducts located completely inside the building thermal envelope
- × 403.2.2 – Sealing
  - + All ducts, air handlers, filter boxes and building cavities used as ducts shall be sealed in accordance with Section M1601.4.1 IRC
  - + Duct tightness shall be verified by testing
    - × Postconstruction or rough-in
    - × The test is not required where the air handler and entire duct system are located within conditioned space.

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### 403.4 – CIRCULATING HOT WATER

- × Insulation
  - + All hot water piping shall be R-2 min
- × Controls
  - + Automatic controls OR
  - + Readily accessible manual switch

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### 403.6 AND 403.7 – SIZING, MULTIPLE UNITS

- × Sizing
  - + Heating and cooling equipment shall be sized in accordance with Section M1401.3 of the IRC
    - Use Design conditions specified in IECC Chapter 3.
    - "Part IV—Mechanical" of the IRC refers specifically to the Air Conditioning Contractors of America (ACCA) Manual J for building loads (IRC Section M1401.3).
    - "Part IV—Mechanical" of the IRC refers specifically to the Air Conditioning Contractors of America (ACCA) Manual S for sizing equipment (IRC Section M1401.3).
- × Multiple Units
  - + All systems serving multiple dwelling units shall comply with Sections 503 and 504 in lieu of Section 403

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### OVERSIZING = SHORT CYCLING

Oversized Air Conditioning Equipment Results in Short Cycling

Impacts of oversizing are:


- Reduces equipment life
- Reduces efficiency (SEER)
- Results in poor dehumidification
- Reduces filter effectiveness

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Figure 35: Presentations to BPI, February 2012 (continued)

### 403.8 - SNOWMELT SYSTEMS



- ✱ Snow and ice-melting equipment controls
  - +Automatic controls capable of shutting down the system when
    - ✱The pavement temperature is above 50°F and no precipitation is falling AND
    - ✱An automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F



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### 403.9 – POOLS


Energy conservation requirements are required for residential pools the same as commercial pools. These include pool heaters, time switches to control circulation pumps and heaters and vapor retardant pool covers

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### 403.9.1 POOL HEATERS


- All pool heaters shall be equipped with a readily accessible on-off switch to allow shutting off the heater without adjusting the thermostat setting. Pool heaters fired by natural gas shall not have continuously burning pilot lights.



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### 403.9.2 TIME SWITCHES.



- Time switches to automatically turn off and on heaters and pumps according to a preset schedule shall be installed on swimming pool heaters and pumps. The two exceptions address public health standards and circumstances where the pumps serve pools with solar-waste-heat recovery heating systems.



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### 403.9.3 POOL COVERS



- Heated pools shall have a vapor-retardant pool cover on or at the water surface
- Pools heated to more than 90°F shall have a R-12 min value pool cover
- Exception
  - Pools deriving over 60 percent of the energy for heating from site-recovered or solar energy source

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### 404.1 - LIGHTING EQUIPMENT

A minimum of fifty percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps.

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Figure 35: Presentations to BPI, February 2012 (continued)





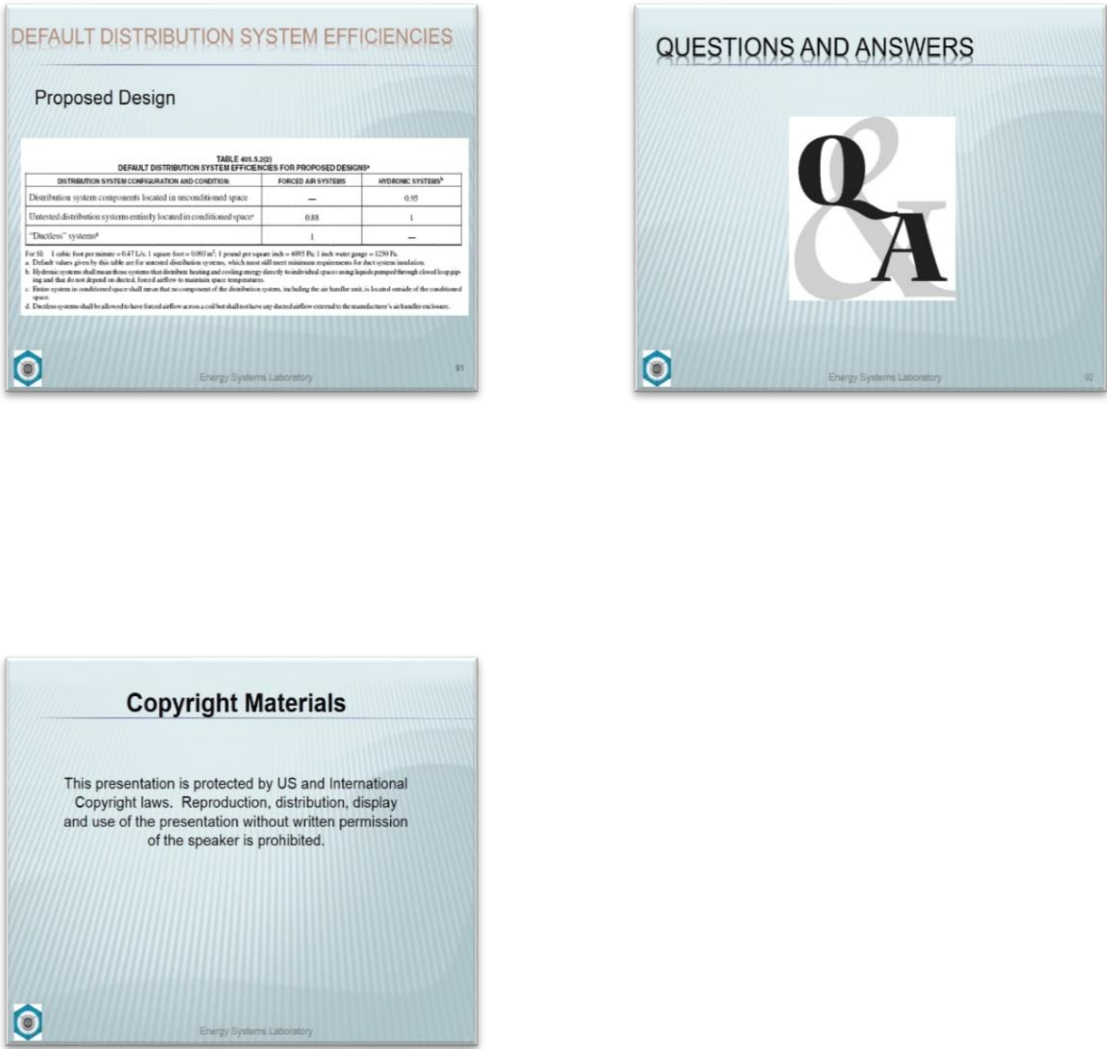


Figure 35: Presentations to BPI, February 2012 (continued)

Presentation to the BPI, May 2012

Building Professional Institute  
May 23, 2012

## Common Sense Construction Using the Energy Code

**Shirley (Muns) Ellis**  
shirleyellis@tamu.edu

- Energy Codes Specialist, Energy Systems Laboratory, Texas Engineering Experimental Station, Texas A&M
- Certified Building Official, since 1987
- Served on the ICC International Energy Conservation Code Development Committee
- 20+ years as a Building Inspector/Official, including residential, high-rise, commercial and industrial
- Instructor for ICC Code training – Code Development, Building, Residential, Energy code and Green Building and Sustainability training


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## Impact of Buildings

- 6 million single-family housing starts permitted in United States
- \$244 billion in private non-residential construction
- The average home emits twice as many greenhouse gases (GHG) as the average car



Source: 2010 US Census

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## Benefits to Communities

- Lowers production of Green House gases & particulates
- Decreases need to construct new power plants
- Reduces peak load demand (increases system reliability)
- Keeps energy dollars in communities
- Improves building stock

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## Benefits to Builders

- Promotes good construction practices
- Increases competitive advantage
- Reduces callbacks
  - Due to properly-installed systems
- Codes provide consistent requirements across jurisdictions

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Figure 36: Presentation to BPI, May 2012

### Benefits to Consumers

- Lower utility costs
- Increased comfort
- Reduced air leakage
- Less extreme surface temperatures
- Low Maintenance/Durable
- Increased equipment life

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### What are Codes?

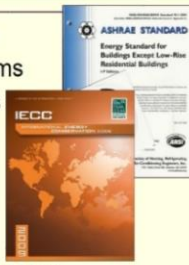
#### What are the IECC and ASHRAE?

- Minimum standards for energy efficiency
  - The least efficient building legally permissible

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### Energy Code Components

- Building envelope
- Mechanical systems
- Electrical systems
- Water heating



Energy Systems Laboratory

### What Codes Are Not?

- Product specific
  - Type of fuel for appliances
  - Recycled content
- NOT state-of-the-art criteria
- Do not regulate "cosmetic" items
  - Paint
  - Carpet

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### Did You Know?

- Homes built in the 21st century will be judged by how well they perform



Energy Systems Laboratory 13

### This is a lofty concept



Where does the rubber meet the road?  
Just how do you design and build "beyond code"?



Figure 36: Presentation to BPI, May 2012 (Continued)

### Beyond Code: What's Attainable?

- Building to these specifications means 30-50% lower energy consumption
  - USGBC LEED (Leadership in Energy and Environmental Design)
  - NAHB Green Building Standard
  - Energy Star
  - Green Building Initiative

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### How to Build Above Code

- Establish design philosophy
- Start at pre-design stage
- Use Life-Cycle-Cost Analysis
- Seek technical assistance
- Recruit vendors and suppliers
- Increase capital budget?
  - Not always

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### High Performance Homes are ...

- Healthy
- Safe
- Efficient
- Durable/Low maintenance
- Comfortable

Energy Systems Laboratory

### Why "Green"?

**Green Buildings Save:**

Category	Savings
ENERGY SAVINGS	30%
CARBON SAVINGS	35%
WATER USE SAVINGS	30-50%
WASTE COST SAVINGS	50-90%

Energy Systems Laboratory

Energy Systems Laboratory

### Orientation

- Where is the sun?
  - This morning?
  - Yesterday?
  - Last Christmas?

Solar Altitude: Angle above the horizon

SOLSTICE Summer/Winter

EQUINOX Spring/Fall

Solar Azimuth: Angle from true south

Energy Systems Laboratory

Figure 36: Presentation to BPI, May 2012 (Continued)



### Size Matters

- Small can be beautiful
- Oil, gas and electricity are not going to get cheaper



Energy Systems Laboratory 21

### Keep Heat Out

- Windows
- Reflective roofing
- Radiant barriers
- Shade
- Insulation
  - Installation quality
  - Total-fill solutions
  - Framing alternatives



Energy Systems Laboratory 22

### Outdoor Space


- Porches
- Living areas



Energy Systems Laboratory 23

### Create outdoor rooms

to increase living space



Energy Systems Laboratory

### Create outdoor rooms

to discourage long-term visitors



Energy Systems Laboratory

### The Big Picture



- Codes
- Design
  - Size/Orientation
- Control Moisture
- Control Air Leakage
- Efficient HVAC
  - Size/Duct installation
- Minimize additional loads

8004


Figure 36: Presentation to BPI, May 2012 (Continued)

### Information Needed on Plans

- Sizes & types of windows/glazed doors
- Window/Door  $U$ -value and SHGC
- Caulking and sealing notes
- Insulation  $R$ -values and protection notes
- Equipment size, types, efficiencies, locations
- Thermostat type
- Duct construction, insulation, location and sealing notes
- HVAC piping insulation
- Low-flow shower head and heat trap notes

Energy Systems Laboratory 25

### High Performance Windows



World's Best Window Co.  
ENERGY STAR 2007  
Single Glazed Windows  
Double Glazed Windows  
Product Type: Double Glazed

ENERGY PERFORMANCE RATINGS	
U-Factor (U-Factor)	0.35
Solar Heat Gain Coefficient	0.32

ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	0.51
Air Leakage (A/L)	0.2
Condensation Resistance	51

Energy Systems Laboratory 27

### Conduction Heat Transfer Equation

$$Q = U \times A \times \Delta T$$

- $Q$  – Btu/hr
- $U$  – Overall Heat Transfer Coefficient (Btu/hr/ft<sup>2</sup>/°F)
- $A$  – Surface Area (ft<sup>2</sup>)
- $\Delta T$  – ( $T_{\text{inside}} - T_{\text{outside}}$ )

Energy Systems Laboratory 28

### Example - Walls

- $U$  – R-20 wall and  $U=1/R$ , so...  
 $U=1/20 = .05$  Btu/hr/ft<sup>2</sup>/°F
- $A$  – Wall 40' x 8' = 320 ft<sup>2</sup>  
Assume 20% of wall area is window (64 ft<sup>2</sup>)
- $\Delta T$  – 72°F - 22 °F

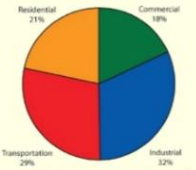
$Q = .05 \times 256 \times (72 - 22) = 640$  Btu/hr  
Now, we need to look at that window

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### National Perspective

- 41 States on track to meet American Recovery and Reinvestment Act (ARRA)
- 10 states with no process to adopt codes underway

Source: BCAP



Energy Use in the U.S.  
Residential 21%  
Commercial 18%  
Transportation 29%  
Industrial 32%  
Data from Energy Information Administration (2007)

Energy Systems Laboratory

### Example - Windows

- $U_{\text{win}} = 0.65$  Btu/hr/ft<sup>2</sup>/°F
- $T$  - Same weather conditions so...

$Q = 0.65 \times 65 \times (72 - 22) = 2080$  Btu/hr !!

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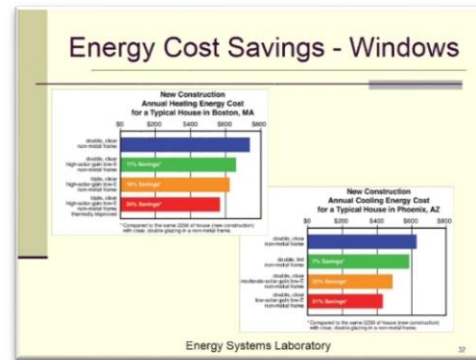
Figure 36: Presentation to BPI, May 2012 (Continued)

### Why Use Good Windows?

- **Total loss for the wall is**
  - $2,080 + 640 = 2,720 \text{ Btu/hr}$

So, **76.5%** of total energy loss is through 20% of the assembly!!

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### Annual Water Vapor Transport

100 sq ft Wall with no Vapor Barrier

Vapor Diffusion: 2/3 pint per heating season

Air Leakage (1/2" hole): 50 pints of water

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### Smart Vapor Retarders

- A blend of nylon compounds that becomes more permeable as humidity increases
- A spray-on, cellulose film reinforced with glass fiber, polyethylene, and latex.
  - Intended as a one-way vapor retarder
  - Not yet commercial

Energy Systems Laboratory 34

### Examples

Energy Systems Laboratory 35

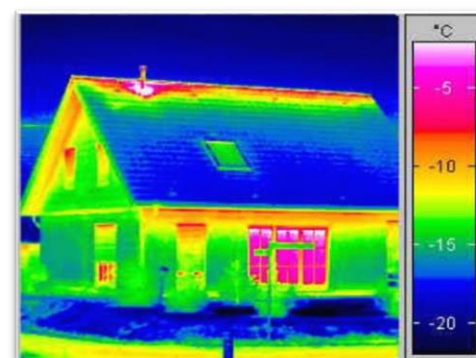


Figure 36: Presentation to BPI, May 2012 (Continued)

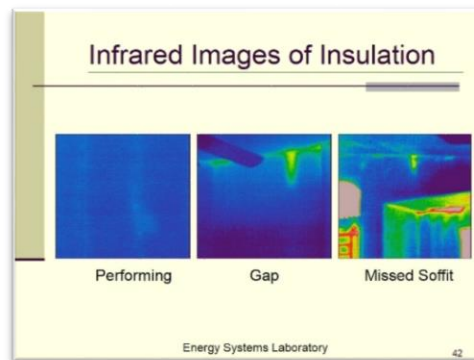
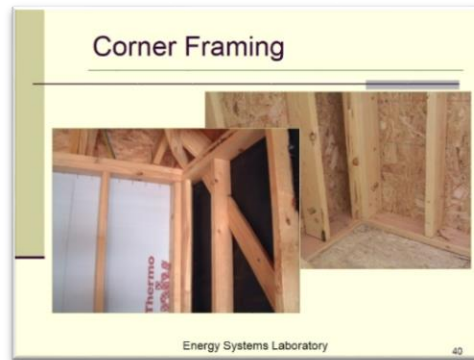
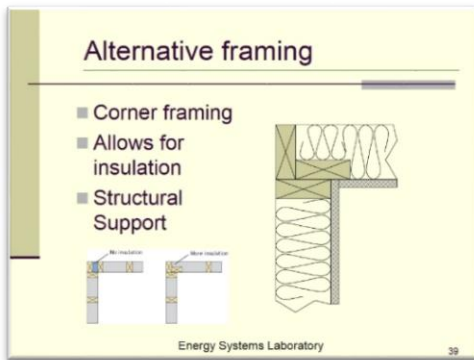
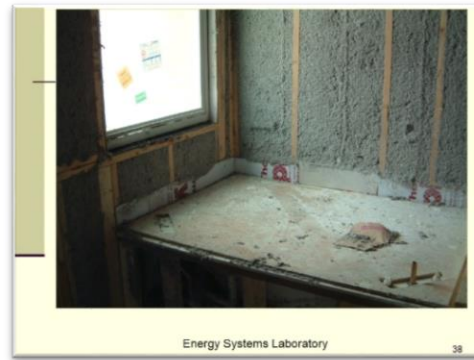


Figure 36: Presentation to BPI, May 2012 (Continued)



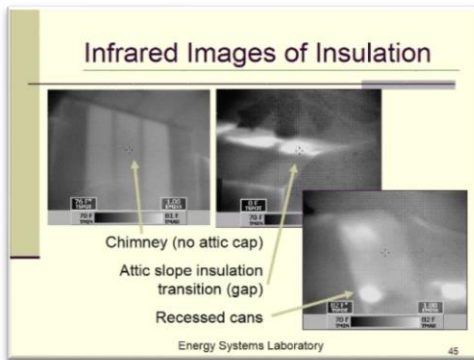
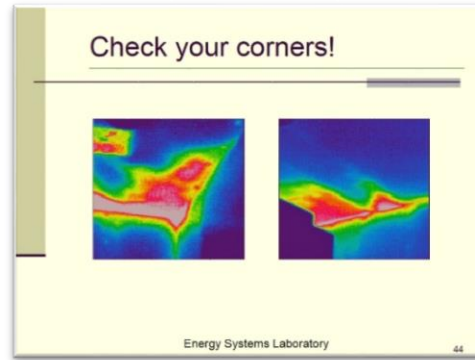
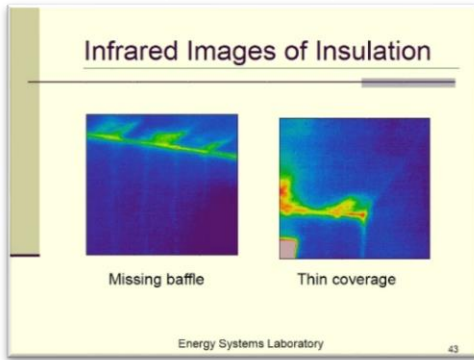


Figure 36: Presentation to BPI, May 2012 (Continued)



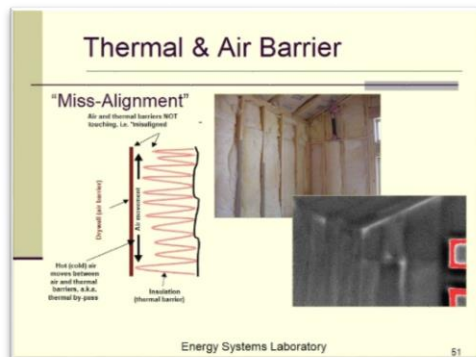
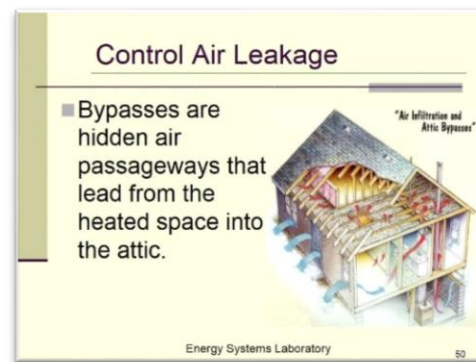
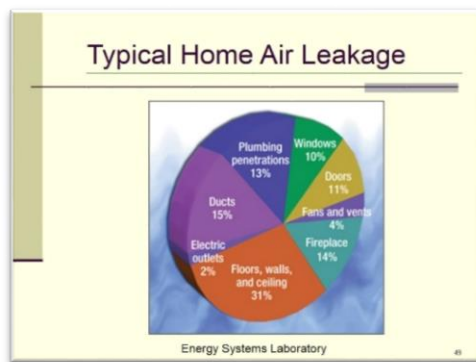


Figure 36: Presentation to BPI, May 2012 (Continued)

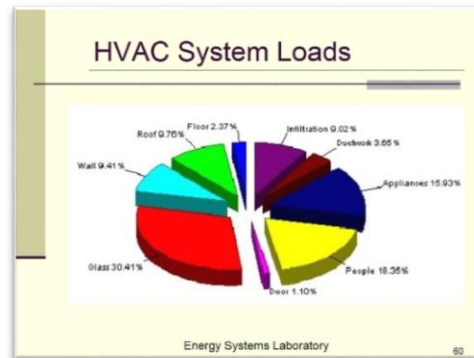
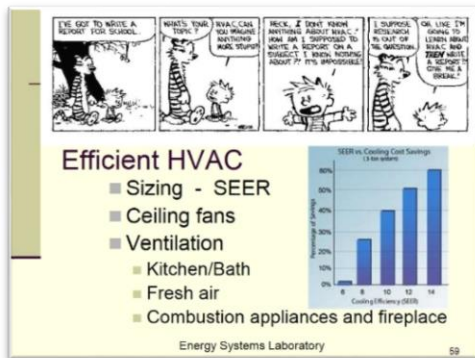
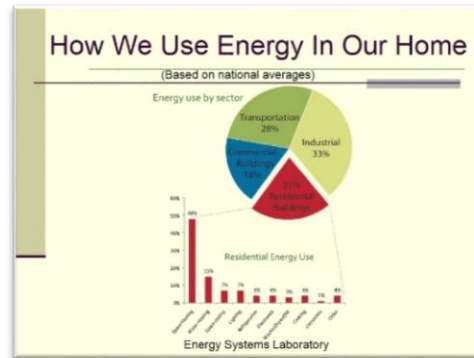
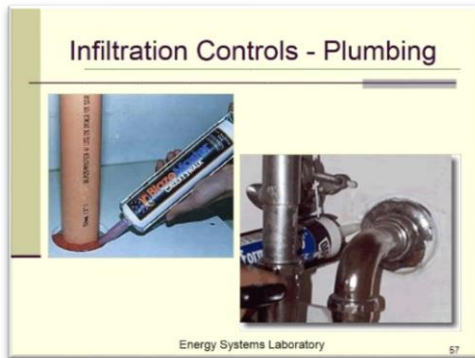


Figure 36: Presentation to BPI, May 2012 (Continued)

### Load Calculation

- Reduced initial cost
- Improved comfort
- Better IAQ, filtration, moisture control
- Less noise
- Lower utility bills/electrical demand

Energy Systems Laboratory 61

### How to Use Your "Rule-of-Thumb" Load Calculator

Directions:

- 1) Cut out on dotted line
- 2) Stand on cutout and look through window to match the house
- 3) Look through window to match the house
- 4) When you get to the largest house.

2 Tons 3 Tons 5 Tons

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### Bigger is Not Better

- Most A/C's are oversized for the house
- Resulting in short cycling
  - Reduces equipment life
  - Reduces efficiency (SEER)
  - Results in poor dehumidification
  - Reduces filter effectiveness

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### Equipment Sizing Case Study

Average AC size ~ 2x what's needed

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This is the past

50% efficient?

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And this is the future

90+% efficient

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Figure 36: Presentation to BPI, May 2012 (Continued)

### System Optimization


- **Natural ventilation** - where AC is not critical
- **Dedicated exhaust** - for areas in the building such as bathrooms, chemical storage, office work rooms
- **Energy Recovery Ventilation** - cost effective in almost all building types
- **System commissioning** - during entire project, re-commission in a year
- **Night flush** - eliminate contaminants and pre-cool building

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### Mechanical Systems

#### Advanced Controls Selection


- Demand Controlled Ventilation
  - Using CO2 Sensors and Variable Fan Drive
- OR
- Occupancy based on/off control



CO2 sensor in return duct

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### HVAC Piping Insulation



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### Ducts

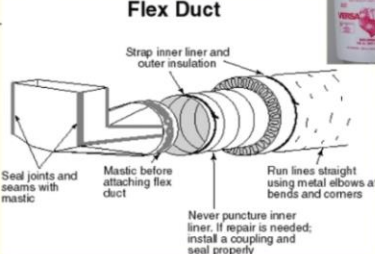
- Sealing
- Short, straight runs
- Inside conditioned space

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### Proper Installation

#### Flex Duct



Seal joints and seams with mastic

Mastic before attaching flex duct

Strap inner liner and outer insulation

Run lines straight using metal elbows at bends and corners

Never puncture inner liner. If repair is needed, install a coupling and seal properly

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### Duct Sealing

- Leakage can increase required HVAC size by about 40%
- Supply leaks draw in hot, moist air - negative pressure
- Return leaks bring air from attic, crawlspace, bypass filter grille
- Cause dust, discomfort, backdrafting, high bills, mold

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Figure 36: Presentation to BPI, May 2012 (Continued)



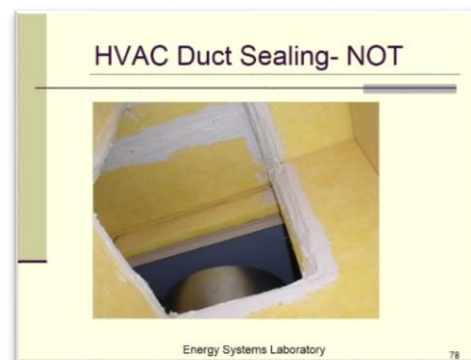
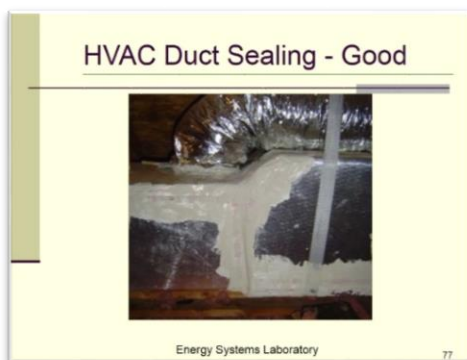
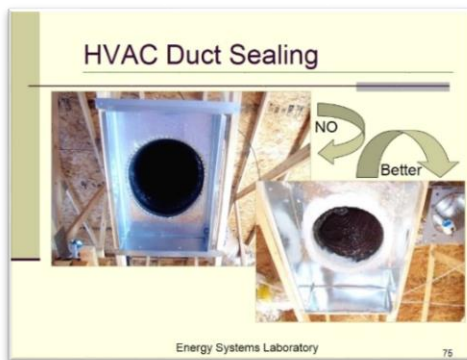
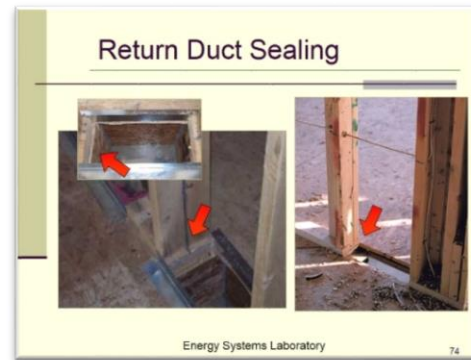


Figure 36: Presentation to BPI, May 2012 (Continued)



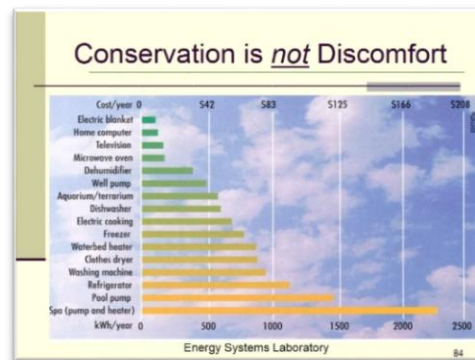
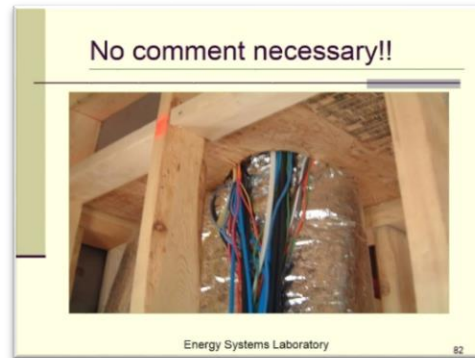
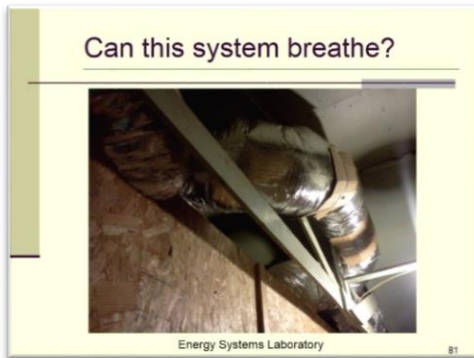
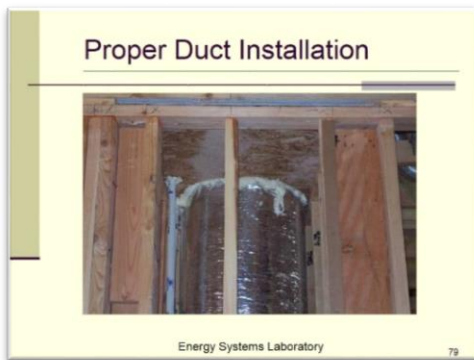


Figure 36: Presentation to BPI, May 2012 (Continued)

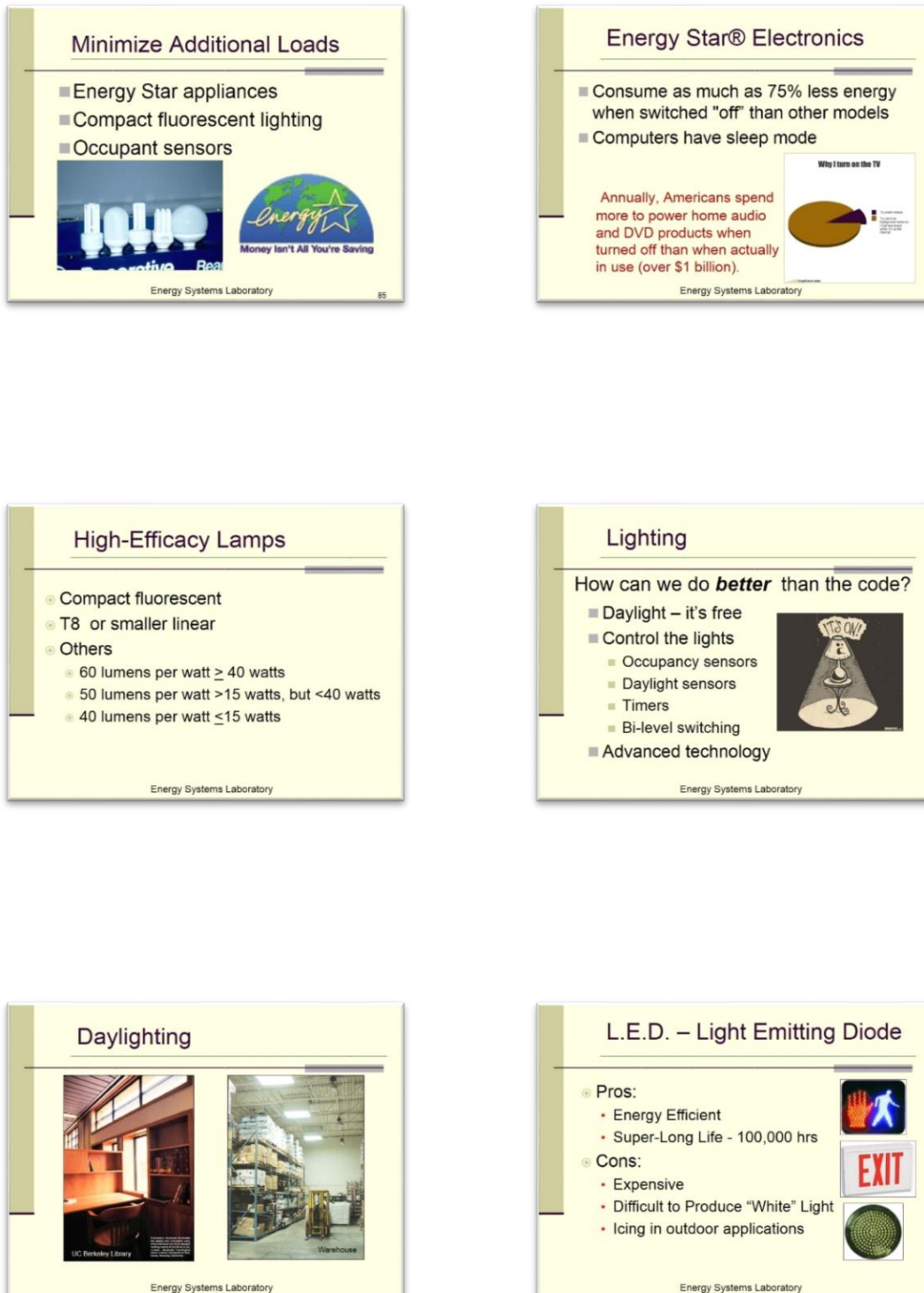
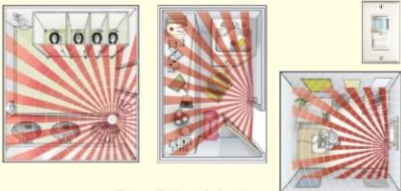


Figure 36: Presentation to BPI, May 2012 (Continued)

### Occupancy Sensors

- Available in Passive-Infrared & Ultrasonic
- Most common problem is misapplication




Energy Systems Laboratory

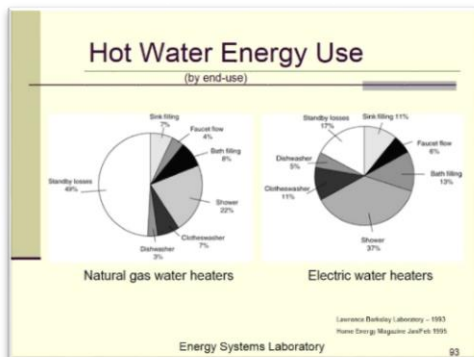
### Water Heating Systems

#### Water heating efficiency

- Heat traps/pipe insulation
- Avoid electric resistance
  - Use heat pump, gas or solar
- No pilot lights
  - Use electronic ignition
- Higher Energy Factor (EF)




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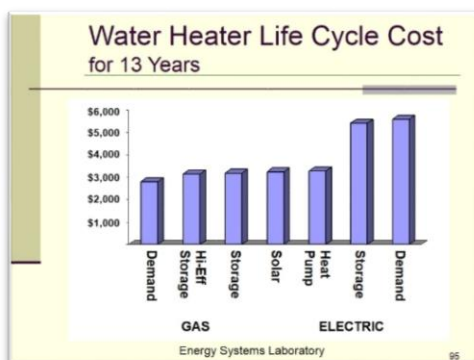


### On-Demand Water Heaters

Electric on-demand heaters require so much power to instantaneously heat water at a reasonable flow and temperature rise, they can actually be the most expensive type of water heater to operate.



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### Know the Signs!

- Poorly detailed or noted drawings
- Sloppy framing
- Excessive waste
- Missing or fake labels



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Figure 36: Presentation to BPI, May 2012 (Continued)

### On Architects & Common Sense

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### On Engineers & Common Sense

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### On Architects and Engineers

*There comes a time in the history of every project when one must shoot the Engineers and Architects and begin actual production.*

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### Summary

- For any building energy efficiency project to meet goals of significant energy savings and a high level of energy code compliance we must:
  - Continue to work together, as a team and in partnership
  - Maintain quality communication
  - Share goals, information and technology
  - Learn from regional, national and international experiences

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### Remember

**Every Building Has Two Price Tags!**

1. The purchase price
2. The cost to operate the building over its lifetime

*When adding the two price tags, energy efficient buildings cost much less!*

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Figure 36: Presentation to BPI, May 2012 (Continued)



## Presentation to the City of Corpus Christi, March 2012



Figure 37: Presentation to the City of Corpus Christi, March 2012



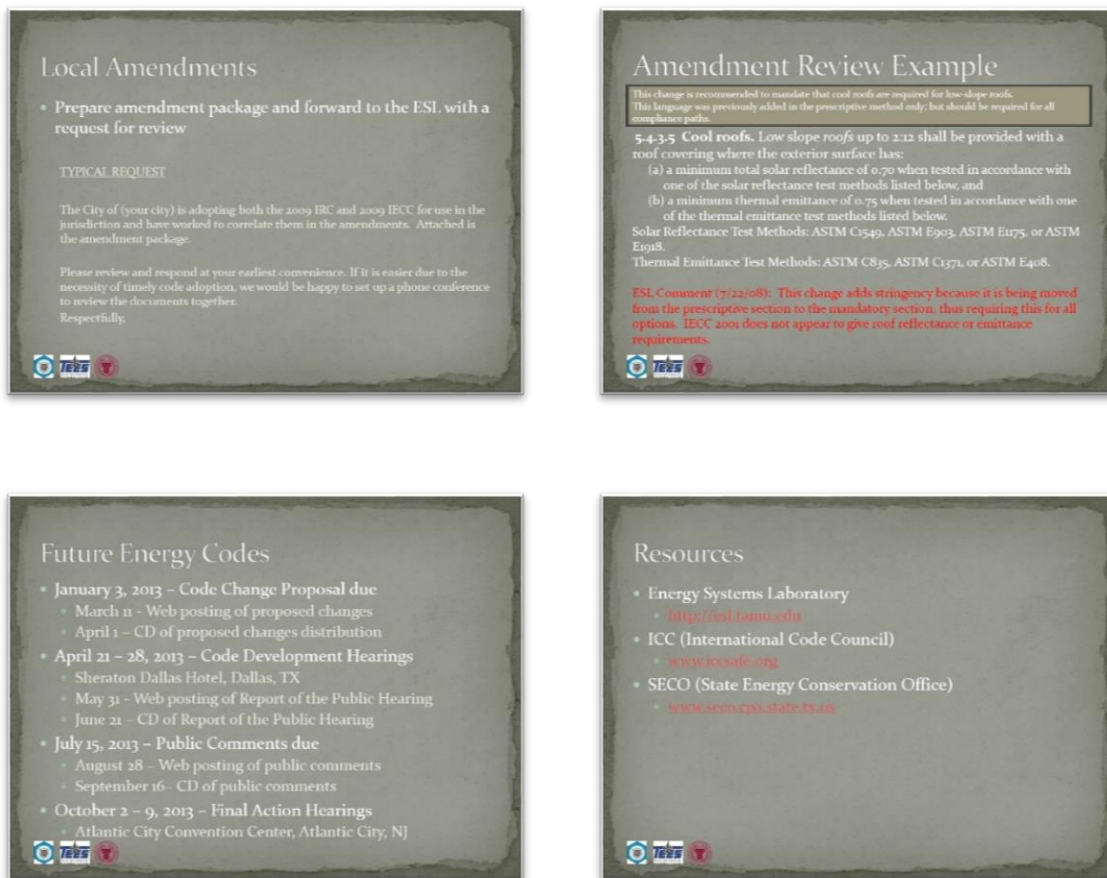


Figure 37: Presentation to the City of Corpus Christi, March 2012 (continued)

Presentation to the Sierra Club, June 2012

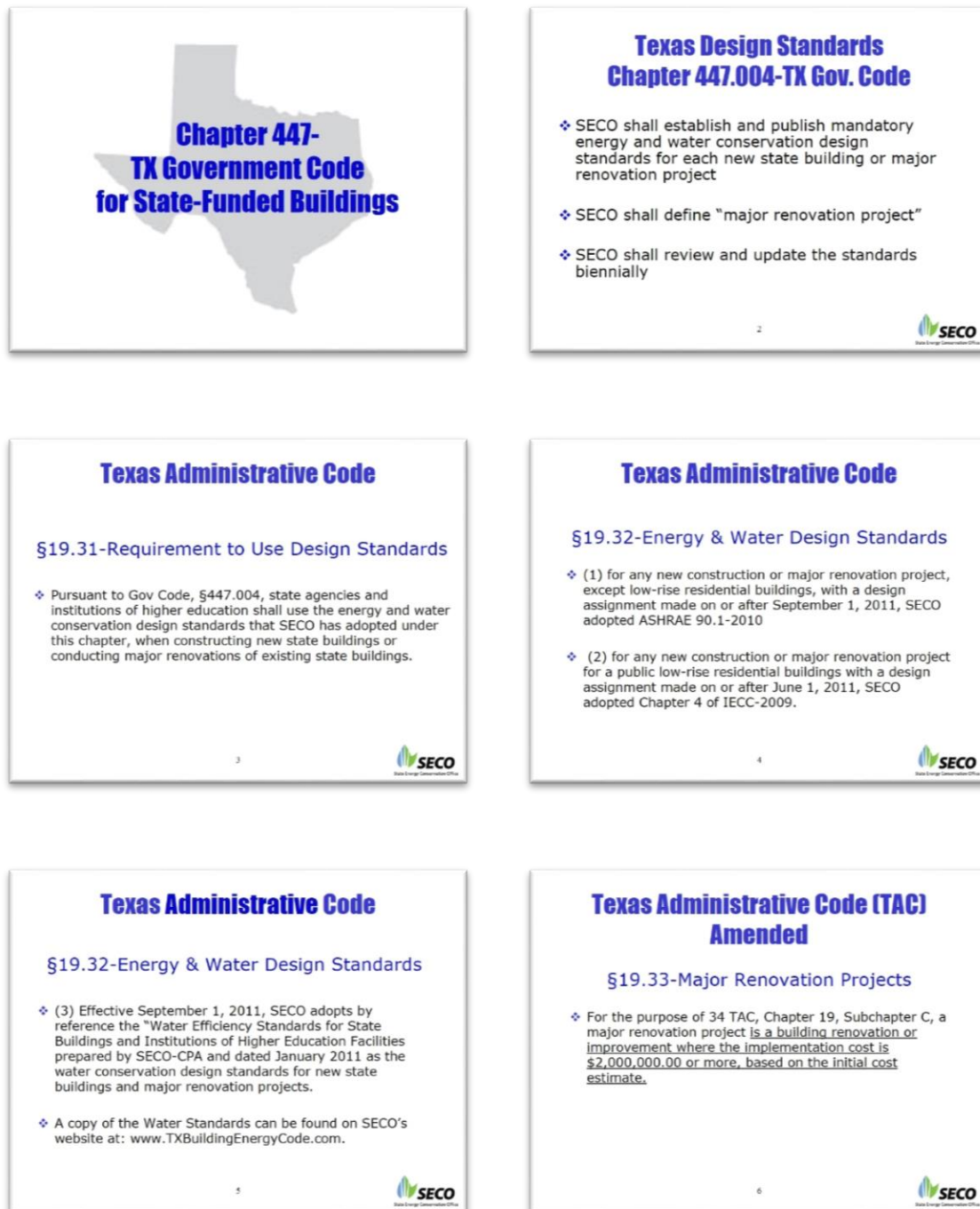



Figure 38: Presentation to the Sierra Club

### Texas Administrative Code (TAC) Amended


#### §19.34-Submission of Certification and Compliance Documentation

- Before beginning construction of a new state building or a major renovation project, including a new building or major renovation project of a state-supported institution of higher education, a state agency or an institution of higher education shall submit to SECO a copy of the certification by the design architect or engineer that verifies to the agency or institution of that the construction or renovation complies with the standards that are established under this chapter, including engineering documentation.

7 

### TX Bldg. Energy Performance Stds. SB 12/HB 3693-2007


- Amended Chapter 388:**
  - Delegated SECO the authority to adopt by rule the latest published editions of:
    - Energy requirements (Chapter 11) International Residential Code (IRC) for single-family construction.
    - International Energy Conservation Code (IECC) for other residential and commercial construction.
  - ESL reviews latest ICC editions to ensure stringency of the IRC and IECC compared to current adopted statewide energy codes.
  - Provides SECO a written recommendation based on analysis and public review.
- Cities can continue to adopt local amendments**
  - Review by the Energy Systems Laboratory (ESL) of the Texas A&M University

8 

### TX Bldg. Energy Performance Stds. ICC Published New IECC-IRC


In 2009 ICC published new editions, triggering the SECO review and energy codes update process:

- January:** IECC 2009 edition published
- March:** IRC 2009 edition published
- May:** Initial 30 days comment period on IECC
  - all comments were provided to ESL for a recommendation to SECO
- July:** initial 30 days comment period on IRC
  - all comments were provided to ESL for a recommendation to SECO.
- September:** ESL recommended SECO the adoption of Chapter 11 of the 2009 IRC and 2009 IECC

9 

### TX Bldg. Energy Performance Stds. SECO Rulemaking

- January-2010:** stakeholder meeting held to gain input prior to draft rule publication.
- March 2010:** draft rule published for 30 days comment.
  - 1,057 sets of comments received
    - Elected officials, trade associations, builders, architects, environmental advocates
- June-2010:** final rule published


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### TX Bldg. Energy Performance Stds.


**Final Rule: §19.53. Building Energy Efficiency Performance Standards**


(a) **Single-family residential construction. Effective January 1, 2012,** the energy efficiency provisions (Chapter 11) of the **International Residential Code** as they existed on May 1, 2009, are adopted as the energy code in this state for single-family residential construction as it is defined in Health and Safety Code, §388.002(12).

(b) **All other residential, commercial, and industrial construction. Effective April 1, 2011,** the **International Energy Conservation Code** as it existed on May 1, 2009, is adopted as the energy code for use in this state for all residential, commercial, and industrial construction that is not single-family residential construction under subsection (a) of this section.

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### 2012 Under Review



 The 2012 IECC and IRC are currently under review by Energy Systems Laboratory.



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Figure 38: Presentation to the Sierra Club (Continued)


### TXBuildingEnergyCode.org




**SECO's Building Energy Code Website provides:**

- ❖ A brief video highlighting the changes in the new energy code
- ❖ Online education and workshop registration
- ❖ Notices and announcements of the latest changes in Texas energy code
- ❖ A history of energy codes in Texas and the rulemaking process
- ❖ Code resources for state-funded buildings, commercial and residential construction, and single-family residences

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### TXEnergyCodeTraining.org



**Texas Energy Code Training Center offers:**

- ❖ Online workshop registration for statewide classes on the new codes;
- ❖ Six online training courses covering residential 2009 IECC, commercial 2009 IECC, air sealing and blower doors;
- ❖ A resource library of compliance tools, software, and PNNL checklists.


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### Questions?


**Felix Lopez, P.E.**  
 State Energy Conservation Office  
 512-463-1080  
[felix.lopez@cpa.state.tx.us](mailto:felix.lopez@cpa.state.tx.us)  
[www.seco.cpa.state.tx.us](http://www.seco.cpa.state.tx.us)

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### Thank You!

**Bahman Yazdani, P.E., CEM**  
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[www.esl.tamu.edu](http://www.esl.tamu.edu)



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Figure 38: Presentation to the Sierra Club (Continued)

## Presentation –TERP Stakeholder’s Meeting, July 2012



Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



### 2009 IECC and 2009 IRC, Chapter 11

- 2009 ICC published new editions, triggering the SECO review and energy codes update process:
  - January: 2009 IECC published
  - March: 2009 IRC published
  - May: 30 days comment period on IECC
    - All comments were provided to ESL for a recommendation to SECO
  - July: 30 days comment period on IRC, Chapter 11
    - All comments were provided to ESL for a recommendation to SECO
  - 1,057 sets of comments received from elected officials, trade associations, builders, architects, environmental advocates
  - September: ESL recommended SECO the adoption of the 2009 IECC and 2009 IRC, Chapter 11
    - January-2010: SECO Stakeholder meeting
    - Allow input to draft rule prior to publication
    - March 2010: 30 days comment period for draft rule published
    - June-2010: Final rule published

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### Texas Building Energy Efficiency Performance Standards (TBEPS)

- §19.53. Building Energy Efficiency Performance Standards
  - (a) Single-family residential construction. Effective January 1, 2012, the energy efficiency provisions (Chapter 11) of the International Residential Code as they existed on May 1, 2009, are adopted as the energy code in this state for single-family residential construction as it is defined in Health and Safety Code, §388.002(12)
  - (b) All other residential, commercial, and industrial construction. Effective April 1, 2011, the International Energy Conservation Code as it existed on May 1, 2009, is adopted as the energy code for use in this state for all residential, commercial, and industrial construction that is not single-family residential construction under subsection (a) of this section

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### 2012 IECC and 2012 IRC, Chapter 11

- ICC publishes a new edition, which triggers the SECO rule-making process:
  - May, 2011: 2012 IECC published
  - July, 2011: 2012 IECC available
  - Dec, 2011: ESL provided a written recommendation to SECO
  - SECO: 30 day public comment period on code recommendation published in Texas Register
    - March 30 – April 30, 2012
    - May 15, 2012 Comments forwarded to ESL for review and recommendation
  - ESL will provide final recommendation on stringency to SECO
  - SECO will publish rule in Texas Register

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### Local Amendments

- Prepare local amendment package and forward to the ESL with a request for review

**TYPICAL REQUEST**  
 The City of (your city) is adopting both the 2012 IRC and 2012 IECC for use in the jurisdiction and has worked to correlate them in the amendments. Attached is the amendment package.

Please review and respond at your earliest convenience. If it is easier due to the necessity of timely code adoption, we would be happy to set up a phone conference to review the documents together.

Respectfully,

Energy Systems Laboratory 7/17/2013

### Amendment Review Example

This change is recommended to mandate that roof roofs are required for low-slope roofs. This language was previously added in the prescriptive method only, but should be required for all compliance paths.

**5.4.3.5 Cool roofs.** Low-slope roofs up to 2:12 shall be provided with a roof covering where the exterior surface has:

- (a) a minimum total solar reflectance of 0.70 when tested in accordance with one of the solar reflectance test methods listed below; and
- (b) a minimum thermal emittance of 0.75 when tested in accordance with one of the thermal emittance test methods listed below.

Solar Reflectance Test Methods: ASTM C1549, ASTM E903, ASTM E1175, or ASTM E1918.  
 Thermal Emittance Test Methods: ASTM C835, ASTM C1371, or ASTM E408.

ESL Comment (7/22/08): This change adds stringency because it is being moved from the prescriptive section to the mandatory section, thus requiring this for all options. IECC 2001 does not appear to give roof reflectance or emittance requirements.

Energy Systems Laboratory 7/17/2013

### 2012 INTERNATIONAL ENERGY CONSERVATION CODE

Significant Changes, DOE Comments

Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

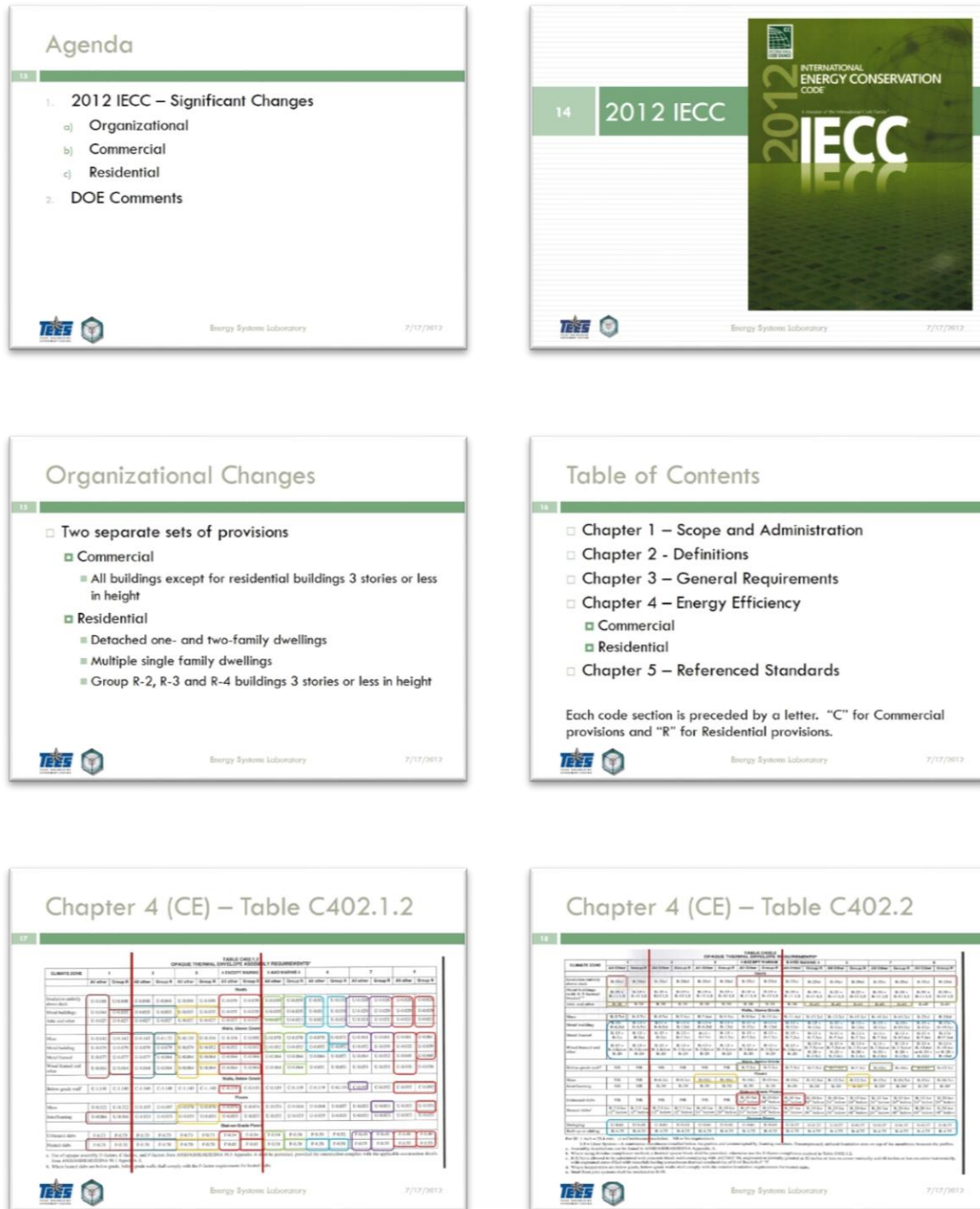


Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

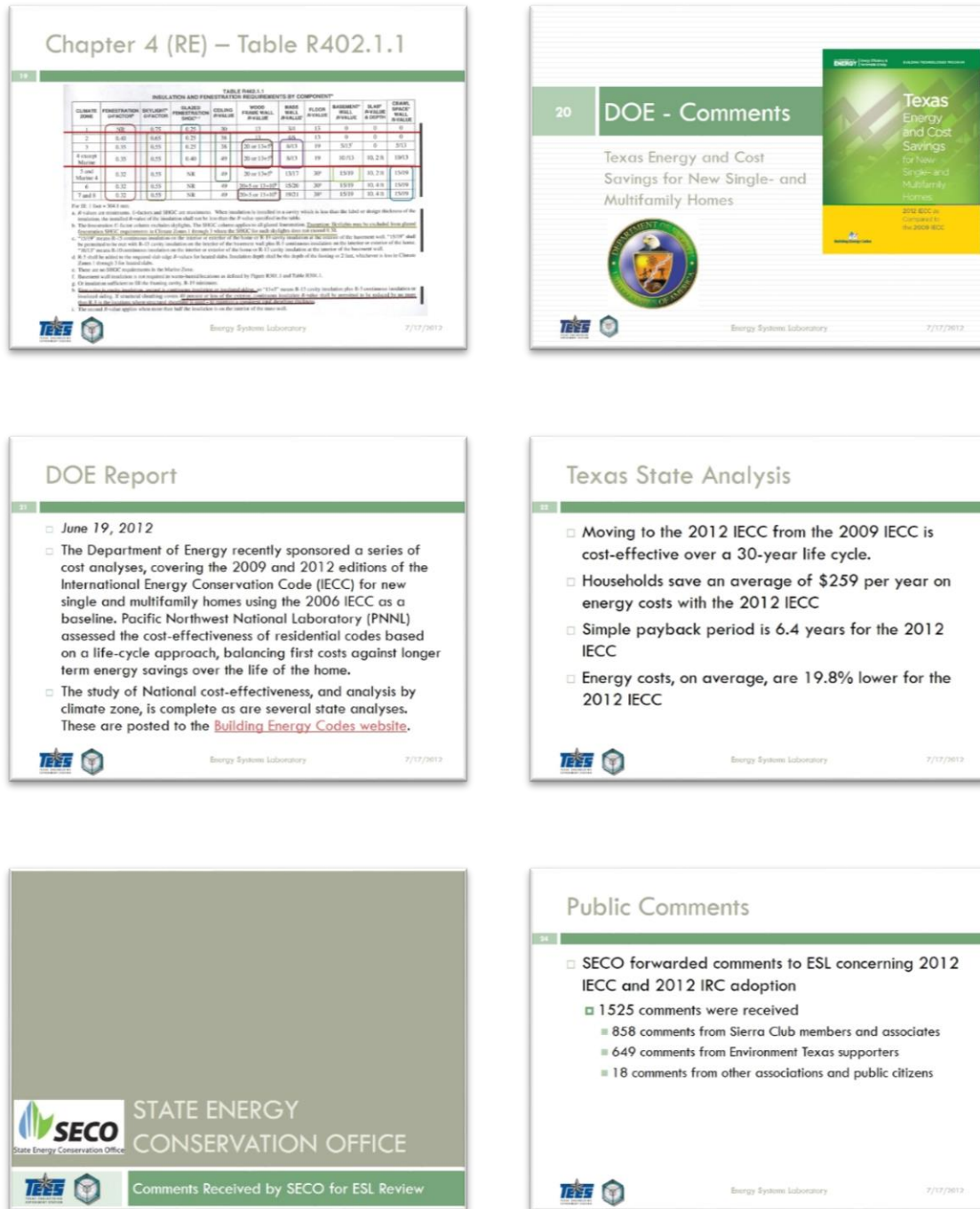


Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



Figure 39: Presentation –TERP Stakeholder's Meeting, July 2012 (Continued)

### 2015 IECC and IRC Code Change Schedule

- January 3, 2013 – Code Change Proposal due
  - March 11 - Web posting of proposed changes
  - April 1 – CD of proposed changes distribution
- April 21 – 28, 2013 – Code Development Hearings
  - Sheraton Dallas Hotel, Dallas, TX
  - May 31 - Web posting of Report of the Public Hearing
  - June 21 – CD of Report of the Public Hearing
- July 15, 2013 – Public Comments due
  - August 28 – Web posting of public comments
  - September 16– CD of public comments
- October 2 – 9, 2013 – Final Action Hearings
  - Atlantic City Convention Center, Atlantic City, NJ

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### Chapter 1- Scope and Administration

Proposed for 2015 IECC


- Commercial
  - C106.2 Conflicting requirements
    - Add exception – when using C401.2 1. ASHRAE 90.1
- Residential

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### Chapter 3 – General Requirements

Proposed for 2015 IECC

- Commercial
- Residential
  - Remove the Warm-Humid designation from the Texas counties located in Climate Zone 2B



- Bandera
- Dimmit
- Edwards
- Frio
- Kinney
- La Salle
- Maverick
- Medina
- Real
- Uvalde
- Val Verde
- Webb
- Zapata
- Zavala

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### Chapter 4 – Energy Efficiency

Proposed for 2015 IECC

- Commercial
  - C402.3.3.1 SHGC Adjustment Multipliers
  - C402.4.1.2 – Air barrier compliance options
    - Resolve conflict between C402.4.1.2.1 (12) and C402.4.1.2.2 (2)
  - C403.2.4.4 Shutoff damper controls
    - Add an exception for kitchen hood dampers meeting the IMC
  - C403.4.1.1 Economizers for Complex Systems
    - Add Air Economizers
  - Table for High-Limit Shutoff Control Options for Air Economizers – inconsistent with ASHRAE 90.1
  - C407 – Total Building Performance
    - Remove and refer to ASHRAE 90.1

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### Chapter 4 – Energy Efficiency

Proposed for 2015 IECC

- Residential
  - Removal of R401.1 Table and require a HERS rating from RESNET
  - R402.4 Air Leakage
    - Use of Table R402.4.1.1
    - Separation of Air leakage inspection from insulation inspection
  - R403.4.2 Hot water pipe insulation - footnotes

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### REVIEW OF AVAILABLE COMPLIANCE SOFTWARE TOOLS

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)







Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

The screenshot shows the IC3 website interface. At the top, the text "IC3 website: ic3.tamu.edu" is displayed. Below this, the website header includes the IC3 logo and navigation links. The main content area is titled "Single Family Home" and "Pricing Single-Family Project". It contains a form for entering energy data, including fields for "Choose Your Energy Code" (set to IECC 2006), "How many bedrooms" (set to 3), and "How many bathrooms" (set to 2). A "Calculate" button is present. Below the form, there is a "Sign Up Now" section with a "Sign Up" button. A sidebar on the right features a Texas state logo and a link to "Energy Audit". The footer includes the "Energy Systems Laboratory" logo and the date "7/17/2013".

# Information Needed for IC3 Project

4

1. County, energy code
2. Number of floors, Number of Bedrooms
3. Foundation type and insulation
4. Window SHGC and U-Factor
5. Wall and duct insulation values
6. Siding Type
7. Roof Type, Area, and insulation
8. Heater, A/C, and water heater specifications
9. Blower door and duct blaster test results
10. For each floor
  - Area, Perimeter, Ceiling height
  - For each side of the floor
    - Area of windows
    - Horizontal projections



 

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[illegible]

# The Certificate

RESIDENTIAL ENERGY EFFICIENCY CERTIFICATE		TEST ENERGY LABORATORY
	Plan ID	test
	Window U-Value	U-0.35
	Window SHGC	0.32
	Wall Cavity Insulation	R-15
	Roof/Ceiling Insulation	R-38"
	Floor/Foundation Insulation	NA
	Supply Duct Insulation	R-6
	Return Duct Insulation	R-6
	"If applicable	
	Heating Efficiency	SEER 15
	Heating Efficiency	Heat Pump System HSPF-10.00
	Water Heater Efficiency	Natural Gas Water Heater EP-0.90
	Certificate Number	761246
	Builder Email	test@test.com
	Builder Phone	1234567890
	Date issued	7/11/2012
	Builder or Registered Design Professional	
This certificate was generated by ICC3 in compliance with IECC 2006 Section 601.3		

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# The Energy Report

[illegible]

Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

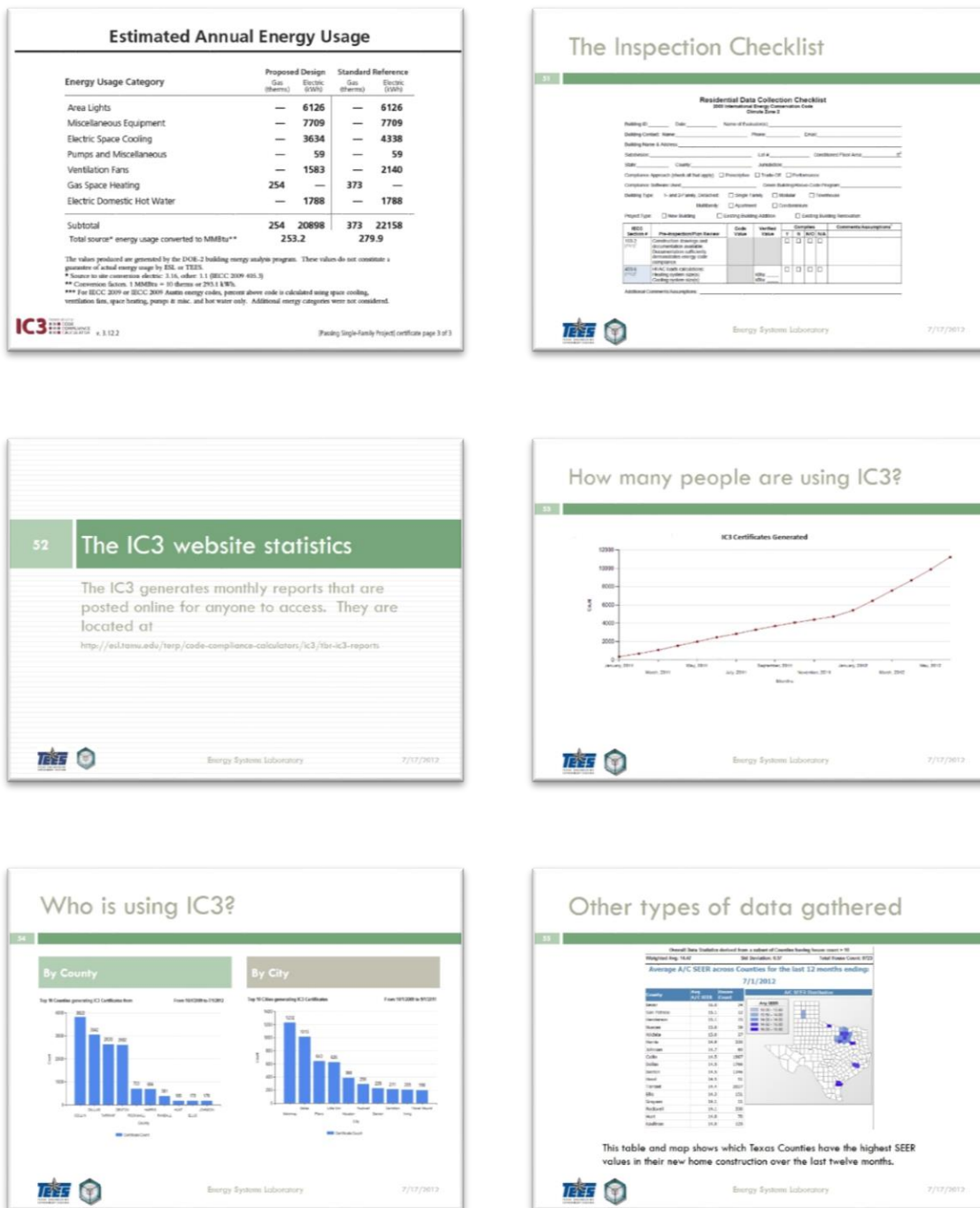


Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

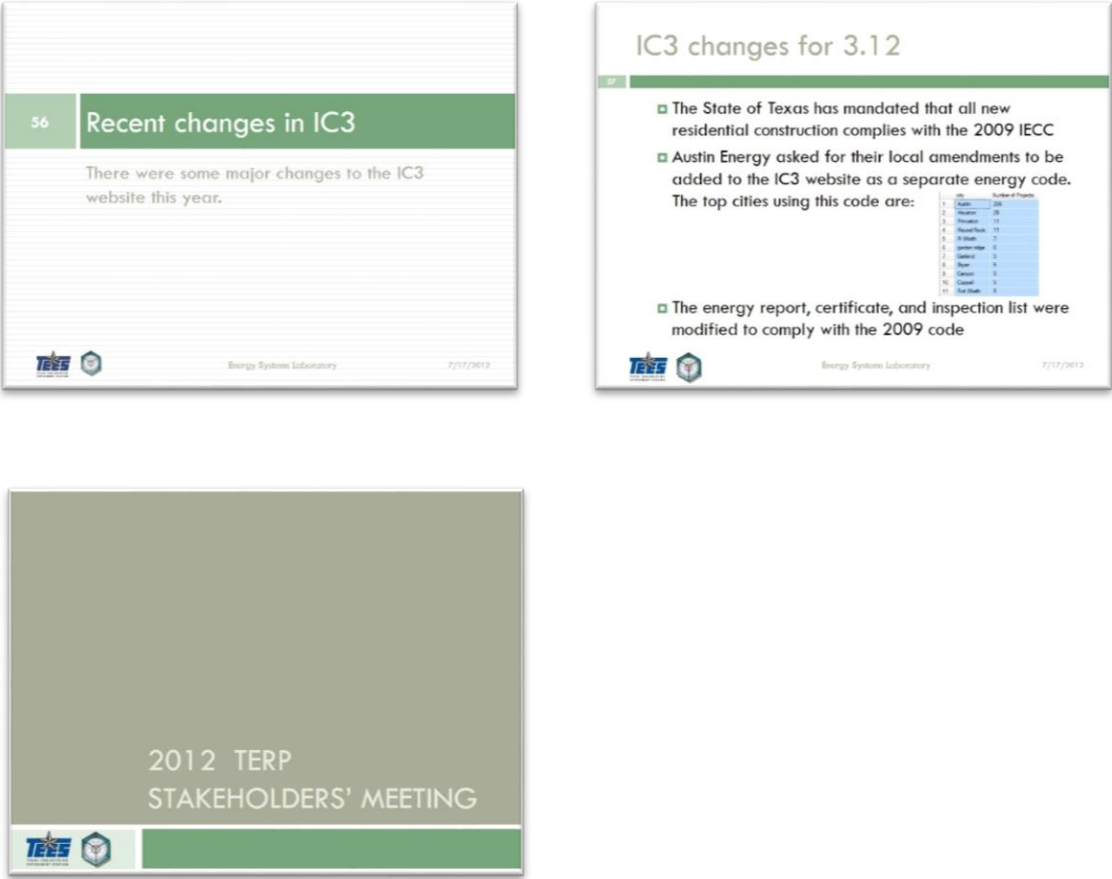


Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



### Chapter 1 (CE) Scope and Administration

- C101.2 Scope
  - Applies to commercial buildings
- C101.3 - Intent
  - Added - over the useful life of each building
- C106.1 - Referenced codes and standards
  - Adds two subsections and clarifies when standards are to be considered
    - C106.1.1 Conflicts
    - C106.1.2 Provision in referenced codes and standards

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### Chapter 2 (CE) Definitions

- Revised definitions
  - Buildings - added - including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building
  - Skylight - changed measurement from a slope of 15° or more from vertical to 60° or less from horizontal
  - Storefront - added - with or without muller windows and doors

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### Chapter 2 (CE) Definitions

- New definitions
  - Building Commissioning
  - Building Entrance
  - Building Site
  - Coefficient of Performance (COP) - Cooling
  - Coefficient of Performance (COP) - Heating
  - Continuous Air Barrier
  - Demand Recirculation Water System
  - Dynamic Glazing
  - Fenestration Product, Field-Fabricated
  - Fenestration Product, Site-Built
  - Furnace Electricity Ratio
  - General Lighting
  - Integrated Part Load Value (IPLV)
  - Nonstandard Part Load Value (NPLV)
  - On-Site Renewable Energy
  - Residential Building
  - Skylight
  - Visible Transmittance (VT)

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### Chapter 3 (CE) General Requirements

- Revised C303.1.3 Fenestration product rating
  - Added Visible Transmittance (VT) to the NFRC 200

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

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### Chapter 4 (CE) Commercial Energy Efficiency

- C401.2 Application
  - Projects shall comply with one of the following
    1. ANSI/ASHRAE/IESNA 90.1
    2. Sections C402, C403, C404 and C405, and with either Section C406.2, C406.3, or C406.4
    3. Section C407, C402.4, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C405.7
      - The building energy costs shall be ≤85% of the standard reference design building

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### Chapter 4 (CE) Commercial Energy Efficiency

- C401.2.1 Application to existing buildings
  - Additions, alterations and repairs to existing buildings shall comply with
    1. Sections C402, C403, C404 and C405
    2. ANSI/ASHRAE/IESNA 90.1

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

### Chapter 4 (CE) - Table C402.1.2

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### Chapter 4 (CE) - Table C402.2

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### Chapter 4 (CE) Building Thermal Envelope

15

- C402.2 Specific insulation requirements
  - Added requirements for layering continuous insulation boards
- C402.2.1 Roof assembly
  - Added requirements for skylight curbs to be insulated to level of roofs
  - Exception for curbs included in NFRC assembly

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### Chapter 4 (CE) Building Thermal Envelope

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- C402.2.1.1 Roof solar reflectance and thermal emittance
  - Low-sloped roofs above cooled conditioned space in Climate Zones 1, 2, 3 shall comply with Table C402.2.1.1

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### Chapter 4 (CE) Building Thermal Envelope

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- Exceptions -
  - Portions of roof covered by
    - Photovoltaic systems
    - Solar air or water heating systems
    - Roof gardens
    - Above roof decks
    - Skylights
    - HVAC systems
  - Portions of roof shaded during peak sun angle
  - Portions of roof that are ballasted
  - Roofs where 75% of roof area meets one of the above

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### Chapter 4 (CE) Building Thermal Envelope

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- C402.2.6 Slabs on grade
  - Added requirement for protection of insulation extending away from the building
  - Exception - when the slab on grade is greater than 24" below the finished exterior
- C402.2.8 Insulation of radiant heating systems (new section)
  - Minimum insulation requirements for system components and the floor structures incorporating the heating

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

### Chapter 4 (CE) Fenestration

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- C402.3 Fenestration
  - C402.3.1 Maximum area - reduced to 30%
    - C402.3.1.1 Increased vertical fenestration area with daylighting controls
      - Increase max fenestration to 40% provided
        - No less than 50% of conditioned floor has daylighting
        - Automatic daylighting controls are used
        - VT of fenestration is 1.1 times SHGC
          - Exception - fenestration outside scope of NFRC 200
      - C402.3.1.2 Increased skylight area with daylighting controls - increased to 5%

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### Table C402.3

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TABLE C402.3  
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE	1	2	3	4 (EXCEPT MARINE)	5 (AND MARINE 4)	6	7	8
<b>Vertical fenestration</b>								
<b>E-factor</b>								
Flood fenestration	0.50	0.50	0.46	0.38	0.38	0.36	0.29	0.29
Operable fenestration	0.65	0.65	0.60	0.45	0.45	0.43	0.37	0.37
Entrance doors	1.10	0.83	0.77	0.77	0.77	0.77	0.77	0.77
<b>SHGC</b>								
SHGC	0.25	0.25	0.25	0.40	0.40	0.40	0.45	0.45
<b>Skylights</b>								
<b>E-factor</b>								
E-factor	0.75	0.65	0.55	0.50	0.50	0.50	0.50	0.50
<b>SHGC</b>								
SHGC	0.35	0.35	0.35	0.40	0.40	0.40	NB	NB

NB = No requirement.

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### Chapter 4 (CE) Fenestration

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- C402.3.2 Minimum skylight fenestration area (new section)
  - Enclosed space greater than 10,000 sq. ft.,
  - Directly under a roof with ceiling heights greater than 15 feet, and
  - Used as an office, lobby, atrium, concourse, corridor, storage, gym/exercise center, convention center, auto service, manufacturing, non-refrigerated warehouse, retail store, distribution area, transportation or workshop

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### Minimum Skylights

22

- Total daylight - not less than half the floor area and provide a minimum skylight to daylight of either
  - Not less than 3% of a skylight VT of at least 0.40
  - Provide a minimum skylight effective aperture of at least 1% determined in accordance with Equation 4-1
  - Exceptions

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### Chapter 4 (CE) Fenestration

23

- C402.3.2.1 Lighting controls in daylight zones under skylights (new section)
  - All lighting in the daylight zone shall be controlled by multilevel lighting controls
  - Exceptions
- C402.3.2.2 Haze factor
  - Skylights in listed occupancies shall have a glazing material or diffuser with a measured haze factor greater than 90% when tested according to ASTM 1003
  - Exceptions

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### Chapter 4 (CE) Fenestration

24

- C402.3.3 Maximum U-factor and SHGC
  - Additional language - "Where different windows or glass doors have different PF values, they shall each be evaluated separately"
- C402.3.3.1 SHGC adjustment
  - Where the PF is greater than or equal to 0.2, the required maximum SHGC shall be adjusted using Table C402.3.3.1

TABLE C402.3.3.1  
SHGC ADJUSTMENT MULTIPLIERS

PROJECTION FACTOR	ORIENTED WITHIN 45 DEGREES OF TRUE NORTH	ALL OTHER ORIENTATION
0.2 ≤ PF < 0.5	1.1	1.2
PF ≥ 0.5	1.2	1.6

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

**Chapter 4 (CE) Fenestration**

- C402.3.3.2 Increased vertical fenestration
  - Climate Zones 1, 2, and 3, fenestration located not less than 6' above the finished floor may increase SHGC to 0.40
- C402.3.3.3 Increased skylight SHGC
  - Climate Zones 1 - 6, maximum SHGC 0.60 where located above daylight zones with automated controls

**Chapter 4 (CE) Fenestration**

- C402.3.3.4 Increased skylight *U*-factor
  - When skylights are installed above daylight zones with automatic controls, a maximum *U*-factor
    - 0.9 in Climate Zones 1 - 3
    - 0.75 in Climate Zones 4 - 8
- C402.3.3.5 Dynamic glazing
  - Shall be considered separately from other fenestration
  - SHGC - manufacturer's lowest-rated
  - VT/SHGC ratio - use maximum VT and SHGC

**Chapter 4 (CE) Fenestration**

- C402.3.4 Area-weighted *U*-factor
  - Area-weighted average permitted for each fenestration product category
  - Individual fenestration products from difference fenestration product categories shall not be combined in calculation

**Chapter 4 (CE) Air Leakage**

- C402.4 Air leakage
  - C402.4.1 Air barriers (new section)
    - Continuous air barrier shall be provided
    - Exception - Climate Zones 1, 2 and 3
  - C402.4.1.1 Air barrier construction
    1. Continuous for all assemblies that are the thermal envelope - including joints and assemblies
    2. Air barrier joints and seams shall be sealed
    3. Recessed lighting fixtures shall comply with C404.2.8 and similar penetrations shall maintain the integrity of the air barrier
    - Exception - Compliance with C402.1.2.3 - not required to comply with Items 1 and 3

**Chapter 4 (CE) Air Leakage**

- C402.4.1.2 Air barrier compliance options
  - Comply with C402.4.1.2.1, C402.4.1.2.2, or C402.4.1.2.3
  - C402.4.1.2.1 Materials
    - Joints must be sealed and materials are installed as air barriers in accordance with manufacturer's instructions
    - 3/8" plywood or oriented strand board
    - 1/2" extruded polystyrene insulation board
    - 1/2" foil-back polyisocyanurate insulation board
    - Closed cell spray foam - 1.5 pcf density - 1 1/2" thick
    - Open cell spray foam - 0.4 - 1.5 pcf density - 4.5" thick
    - 1/2" cement board or exterior or interior gypsum board
    - Built-up roofing membrane
    - Modified bituminous roof membrane
    - Fully adhered single-ply roof membrane
    - 5/8" gypsum plaster or Portland cement/sand parge
    - Cast-in-place or precast concrete
    - Full grouted concrete block masonry
    - Sheet steel or aluminum

**Chapter 4 (CE) Air Leakage**

- C402.4.1.2.2 Assemblies
  - Materials and components tested with ASTM E 2357, ASTM E 1677 or ASTM 3 283
  - An average air leakage not to exceed 0.04 cfm, tested at 0.3" w.g.(75 Pa)
- C402.4.1.2.3 Building Test
  - Completed building tested in accordance with ASTM E 779
  - Leakage not to exceed 0.04 cfm, tested at 0.3" w.g. (75 Pa)

Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



### Chapter 4 (CE) Air Leakage

- C402.4.2 Air barrier penetrations
  - Added language clarifying sealing requirements
- C402.4.3 Air leakage of fenestration
  - Table C402.4.3

FENESTRATION ASSEMBLY	MAXIMUM AIR INFILTRATION RATE (l/s/m²)	TEST PROCEDURE
Windows	0.20 <sup>a</sup>	AAMA/WDMA/CSA1011.5.2/4A44
Sliding doors	0.20 <sup>a</sup>	or NFRC 400
Swinging doors	0.20 <sup>a</sup>	
Skylights - with condensation water vapor openings	0.30	
Skylights - all other	0.20 <sup>a</sup>	
Curtain walls	0.06	NFRC 400
Overhead glazing	0.06	ASTM E 283 at 1.57 psf (77 Pa)
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DINMA 101, NFRC 400, or ASTM E 283 at 1.57 psf (77 Pa)
Rolling doors	1.00	

For 10: 1 cubic foot per minute = 0.473 l/s, 1 square foot = 0.093 m².  
<sup>a</sup> The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.20 l/s per square foot of fenestration at door area when tested in accordance with AAMA/WDMA/CSA1011.5.2/4A44 at 5.24 psf (248 Pa).

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### Chapter 4 (CE) Air Leakage

- C402.4.4 Doors and access openings to shafts chutes, stairways and elevator lobbies
  - Exception
- C402.4.5 Air intakes, exhaust openings, stairways and shafts
  - C402.4.5.1 Stairway and shaft vents
  - C402.4.5.2 Outdoor air intakes and exhausts
  - Exceptions

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### Chapter 4 (CE) Air Leakage

- C402.4.7 Vestibules
  - Added all building entrances
  - Added the installation of revolving doors in the building entrance shall not eliminate the vestibule on any door adjacent to the revolving door
  - Exceptions
    - Added doors intended solely for employee use to exception 2

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### Chapter 4 (CE) Air Leakage

- C402.4.8 Recessed lighting
  - Removed language addressing air movement from the conditioned space to the ceiling cavity.



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### Chapter 4 (CE) Mechanical

- C403.2.1 Calculation of heating and cooling loads
  - Added - The design loads shall account for the building envelope, lighting, ventilation and occupancy loads based on the project design
- C403.2.2 Equipment and system sizing
  - Clarified the output capacity of heating and cooling equipment systems shall not exceed the loads calculated

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### Chapter 4 (CE) Mechanical

- C403.2.3 HVAC equipment performance requirements
  - Added - Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of Table C403.2.3(9)
- C403.2.3.1 Water-cooled centrifugal chilling packages
  - Changed the formulas
    - Adjusted minimum full-load COP ratings
    - Adjusted minimum NPLV rating
  - Exception - chillers designed to operate outside these ranges need not comply

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



### Chapter 4 (CE) Mechanical

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- Table C403.2.3(1)
- Table C403.2.3(2)
- Table C403.2.3(3)
- Table C403.2.3(4)
- Table C403.2.3(5)
- Table C403.2.3(6)
- Table C403.2.3(7)
- Table C403.2.3(8)
- Table C403.2.3(9)

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### Chapter 4 (CE) Mechanical

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- C403.2.3.2 Positive displacement (air- and water-cooled) chilling packages (new)
  - Equipment with a leaving fluid temperature higher than 32°F shall meet Table C403.2.3(7)
- C403.2.4.3.3 Automatic start capabilities (new)
  - Controls shall be provided for each HVAC system
  - Capable of automatically adjusting the daily start time in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy

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### Chapter 4 (CE) Mechanical

39

- C403.2.5.1 Demand controlled ventilation
  - Reduced average occupant load to 25 people
- Exception
  - Additional exception where demand control ventilation is not required
    - Ventilation provided for process loads only

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### Chapter 4 (CE) Mechanical

40

- C403.2.6 Energy recovery ventilation systems
  - Required where the supply airflow rate of a fan system exceeds the values specified in Table C403.2.6
  - Changes to Exceptions 5,6, and 7 - added 8 and 9
    - 5. Changed to Climate Zones 1 and 2
    - 6. Changed to Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8
    - 7. Changed to dehumidification that employ energy recovery in series with the cooling coil
    - Where the largest source of exhausted air at a single location is less than 75% of the design outdoor air flow
    - Systems expected to operate less than 20 hrs per week at the outdoor air % covered by Table C403.2.6

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### Chapter 4 (CE) Mechanical

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- Table C403.2.6

CLIMATE ZONE	2 50% and < 60%	2 60% and < 70%	2 70% and < 80%	2 80% and < 90%	2 90% and < 100%	2 100% and < 110%	2 110% and < 120%	2 120% and < 130%	2 130% and < 140%	2 140% and < 150%
1B, 1C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
1B, 2B, 5C	NR	NR	2 20000	2 25000	2 30000	2 35000	2 40000	2 45000	2 50000	2 55000
6B	2 11000	2 15000	2 20000	2 25000	2 30000	2 35000	2 40000	2 45000	2 50000	2 55000
1A, 2A, 3A, 4A, 5A, 6A	2 25000	2 30000	2 35000	2 40000	2 45000	2 50000	2 55000	2 60000	2 65000	2 70000
7, 8	2 25000	2 30000	2 35000	2 40000	2 45000	2 50000	2 55000	2 60000	2 65000	2 70000

NR = not required

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### Chapter 4 (CE) Mechanical

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- C403.2.7.1.3 High-pressure duct systems
  - Changed formula -  $CL = F/p^{0.65}$
- C403.2.8 Piping insulation
  - Changed Table C403.2.8
- Exceptions
  - 3. Increased minimum temperature to 60°F
  - 5. Replaced with new requirements
    - Removed exception for runout piping
    - Strainers, control valves, and balancing valves associated with piping 1" or less
  - 6. Added direct buried piping that conveys fluids at or below 60°F

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



### Chapter 4 (CE) Mechanical

49

- C403.3 Simple HVAC systems
  - Economizers -Exceptions continued
    - Systems that serve residential spaces where the capacity is less than five times the requirement listed in Table C403.3.1(1)

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B	No requirement
2A, 2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	Economizers on all cooling systems $\geq 33,000$ Btu/h <sup>a</sup>

For SI-1 British thermal unit per hour = 0.2931 W.  
a. The total capacity of all systems without economizers shall not exceed 300,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater.

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### Chapter 4 (CE) Mechanical

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- C403.3 Simple HVAC systems
  - Economizers -Exceptions continued
    - Systems expected to operate less than 20 hours a week
    - Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems
    - Where the cooling efficiency meets or exceeds the efficiency requirements in Table C403.3.1(2)

CLIMATE ZONES	COOLING EQUIPMENT PERFORMANCE IMPROVEMENT (SEER OR EPLV)
2B	10% Efficiency Improvement
3B	15% Efficiency Improvement
4B	20% Efficiency Improvement

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### Chapter 4 (CE) Mechanical

51

- C403.3.1.1 Air economizers (new)
  - C403.3.1.1.1 Design capacity
    - System shall be capable of modulating outdoor air and return air dampers to provide up to 100% of design supply air quantity as outdoor air for cooling
  - C403.3.1.1.2 Control signal
    - Dampers capable of being sequenced with the cooling equipment and not controlled only by mixed air temperature
    - Exception
      - Use of mixed air temperature limit control shall be permitted for some systems such as single-zone systems

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### Chapter 4 (CE) Mechanical

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- C403.3.1.1.3 High-limit shutoff
  - Capable of automatically reducing outdoor air intake to the minimum quantity when intake will not longer reduce cooling energy usage
  - High-limit shutoff control types for specific climates shall be from Table C403.3.1.1.3(1)
  - High-limit shutoff control settings for these control types shall be as specified in Table C403.3.1.1.3(2)

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### Chapter 4 (CE) Mechanical

53

- C403.3.1.1.4 Relief of excess outdoor air
  - Capable of relieving excess outdoor air during air economizer operation to prevent over-pressurizing the building.
  - Locate the relief valve to avoid recirculation into the building

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### Chapter 4 (CE) Mechanical

54

- C403.4 Complex HVAC systems
  - C403.4.1 Economizers
    - Removed air economizers
  - C403.4.1.1 Design capacity - water economizers
    - Cooling by indirect evaporation
    - Provide up to 100% of the expected cooling load
    - Outdoor air temperatures of 50°F dry bulb/45°F wet bulb
    - Expected system cooling load at 45°F dry bulb/40°F wet bulb
  - Exception
    - Where dehumidification requirements cannot be met

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

**Chapter 4 (CE) Mechanical**

- C403.4.1.2 Maximum pressure drop
  - Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a water-side pressure drop of less than 15' or a secondary loop shall be created so that the pressure drop is not seen by the circulating pumps, when the system is in the normal (noneconomizer) mode

**Chapter 4 (CE) Mechanical**

- C403.4.1.3 Integrated economizer control
  - Economizers shall be integrated with the cooling system and capable of providing partial cooling
  - Capable of providing partial cooling
    - Even where additional mechanical cooling is required
  - Exception
    - Direct expansion systems that include controls that reduce the quantity of outdoor air required to prevent coil frosting
    - Individual direct expansion units that have a capacity less than 54,000 Btu/h and use nonintegrated controls that preclude simultaneous operations

**Chapter 4 (CE) Mechanical**

- C403.4.1.4 Economizer heating system impact
  - Design and controls shall be such that economizer does not increase the building heating use during normal operation
  - Exception
    - Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature
- C403.4.2 Variable air volume fan control
  - Added driven by a vine-axial fan with variable-pitch blades

**Chapter 4 (CE) Mechanical**

- C403.4.2.1 Static pressure sensor location
  - Sensors used to control VAV fans shall be placed in a position that the controller setpoint is no greater than 1/3 the total design an static pressure
  - Except for systems with zone reset controls
  - Sensors installed down-stream of major duct splits, at lease one-sensor shall be located on each major branch to ensure static pressure can be maintained at each branch

**Chapter 4 (CE) Water Heating**

- C404.5 Pipe Insulation
  - Added heat-traced systems
  - Changed noncirculating systems to non-hot-water-supply temperature maintenance systems
  - Added exception - heat-traced systems shall meet the manufacturer's installation instructions
    - Untraced piping within the heat-traced system shall be insulated
- C404.6 Hot water system controls
  - Changed from when system is not in operation to when there is limited demand
  - Added ready access shall be provided to the operating controls

**Chapter 4 (CE) Water Heating**

- C404.7 Pools and inground permanently installed spas (Mandatory)
  - C404.7.1 Heaters
    - On-off switch to be mounted outside of the heater
  - C404.7.2 Time switches
    - Applies to all, not just swimming pools
    - Heaters, pumps and motors with built in timers shall be deemed in compliance

Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



**Chapter 4 (CE) Water Heating**

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- C404.7.3 Covers
  - Added inground permanently installed spas
  - Removed R-value requirements for pools heated to more than 90°F
  - Exception
    - Not required for pools deriving over 70% of the heating energy from site-recovered energy, such as a heat pump or solar energy source computed over an operating season

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**Chapter 4 (CE) Lighting**

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- C405.1 General
  - Adds electrical energy consumption
  - Exception
    - Increases high efficacy requirement in dwelling units to 75%, exempting low-voltage from that requirement
- C405.2.1 Manual lighting controls
  - Adds requirement that all buildings include manual lighting controls that meet C405.2.1.1 and C405.2.1.2

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**Chapter 4 (CE) Lighting**

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- C405.2.1.2 Light reduction controls
  - Amends exceptions
    - Areas with only one luminaire, added - with rated power less than 100 watts
    - Expands exception for corridors, storerooms, restrooms or public lobbies to include electrical or mechanical rooms
  - Adds daylight spaces complying with C405.2.2.3.2

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**Chapter 4 (CE) Lighting**

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- C405.2.2 Additional lighting controls - each area shall also meet C405.2.2.1, C405.2.2.2 and C405.2.2.3
  - Additional exception - lighting intended for continuous operation

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**Chapter 4 (CE) Lighting**

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- C405.2.2.1 Automatic time switch control devices installed to control lighting in all areas of the building
  - Removed - buildings larger than 5,000 sq. ft.
  - Exceptions
    - Emergency egress lighting
    - Spaces controlled by occupancy sensor
  - Removed Holiday scheduling section and exception

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**Chapter 4 (CE) Lighting**

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- C405.2.2.2 Occupancy sensors
  - Installed in all classrooms, conference/meeting rooms, employee lunch and break rooms, private offices, restrooms, storage rooms and janitorial closets, other enclosed spaces 300 sq. ft. or less
  - Turn off lights within 30 minutes of all occupants leaving the space
  - Manual on or automatically turn the lighting on to not more than 50% power
- Exception
  - Full automatic-on controls permitted in public corridors, stairways, restrooms, primary building entrances areas and lobbies, and where manual-on operation would endanger the safety or security of the room or occupants

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)





**Chapter 4 (CE) Additional Efficiency Package Options (new)**

- C406.1 Buildings shall comply with at least one of the following
  1. C406.1.2 Efficient HVAC Performance
  2. C406.1.3 Efficient Lighting Performance
  3. C406.1.4 On-Site Supply of Renewable Energy
- Individual tenant spaces shall comply with either 1 or 2 unless compliance with 3 for the entire building is demonstrated

**Chapter 4 (CE) Additional Efficiency Package Options**

- C406.2 Efficient HVAC performance
  - Meet the efficiency of C406.2(1) - C406.2(7) in addition to C403
  - Only allowed where the equipment efficiencies in this section are greater than C403
- C406.3 Efficient lighting system
  - Total interior lighting power shall be determined by using Table C406.3 x the floor area for the building type

**Chapter 4 (CE) Additional Efficiency Package Options**

- C406.4 On-site renewable energy
  - Total minimum rating shall comply with one of the following
    - Not less than 1.75 Btu/h or not less than 0.50 watts per sq. ft. of conditioned floor space
    - Not less than 3% of the energy used for building mechanical and service water heating equipment and lighting

**Chapter 4 (CE) Total Building Performance**

- No Changes

**Chapter 4 (CE) System Commissioning (new)**

- C408.1 Commissioning of the building mechanical systems in C403 and electrical power and lighting systems in C405
- C408.2 Mechanical systems commissioning and completion requirements
  - Prior to final mechanical inspection
  - Evidence by a registered design professional
  - Construction document notes clearly indicate provisions
  - Copies of all documents to owner and made available to code official
  - Exceptions
    - Systems in buildings where the total capacity is >480,000 Btu/h cooling and 600,000 Btu/h heating
    - System serving dwelling units and sleeping units in hotels, etc.

**Chapter 4 (CE) System Commissioning - Mechanical**

- C408.2.1 Commissioning Plan
  - Developed by a registered design professional including
    - Narrative of the activities that will be accomplished during each phase, including personnel
    - Listing of specific equipment, appliances or systems to be tested and a description of tests
    - Functions to be tested, including, but not limited to calibrations and economizer controls
    - Conditions under which test will be performed, at a minimum winter and summer design conditions and full outside air conditions
  - Measurable criteria for performance

Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

The figure consists of six presentation slides arranged in a 3x2 grid. Each slide has a green header with the title 'Chapter 4 (CE) System Commissioning' and a small number in the top left corner. The slides contain bulleted lists of technical requirements and procedures. Each slide also features the T&EES logo, 'Energy Systems Laboratory', and the date '7/11/2012' at the bottom.

- Slide 79:** C408.2.2 Systems adjusting and balancing
  - HVAC system shall be balanced in accordance with generally accepted engineering standards
  - Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications
  - Test and balance activities shall include air system and hydronic balancing
- Slide 80:** C408.2.2.1 Air system handling
  - Relocated from 503.2.9.1
  - Added - air systems shall be balance in a manner to first minimize throttling losses, then
  - For fans with system power greater than 1 hp fan speed shall be adjusted to meet design flow conditions
  - Exception
    - fans with fan motors of 1 hp or less
- Slide 81:** C408.2.2.2 Hydronic systems balancing
  - Relocated from 503.2.9.2
  - Added - shall be balanced in a manner to
    - First minimize throttling losses
    - Then the pump impeller shall be trimmed or pump speed adjusted to meet design flow conditions
  - Each hydronic system shall have the capacity to either
    - Measure pressure across the pump
    - Test ports at each side of each pump
  - Exception
    - Pumps with pump motors of 5 hp or less
    - Where throttling results in no greater than 5% of the nameplate horsepower draw above that required if the impeller were trimmed
- Slide 82:** C408.2.3 Functional performance testing
  - C408.2.3.1 Equipment - demonstrate the
    - Installation and operation of components, systems, and system-to-system interfacing, such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed
  - Testing shall include all modes and sequence of operation, including
    - Full-load, part-load and the following emergency
      - All modes described in the sequence of operation
      - Redundant or automatic back-up mode
      - Performance of alarms
      - Mode of operation upon loss and restoration of power
- Slide 83:** C408.2.3.1 Exception - unitary or packaged equipment in C403.2.3 Tables that do not require supply air economizers
- Slide 83:** C408.2.3.2 Controls - tested to document calibration, adjustment, and operation in accordance with plans and specifications for
  - Control devices, components, equipment and systems
- Slide 83:** C408.2.3.3 Economizers - functional test for operations within manufacturer's specifications
- Slide 84:** C408.2.4 Preliminary commissioning report
  - Report of commissioning test procedures and results, provided to the building owner
  - Completed, identified as "Preliminary Commissioning Report" and certified by the registered design professional or approved agency
    - Itemization of deficiencies that have not been corrected at the time of report preparation
    - Deferred tests that cannot be performed due to climatic conditions
    - Climatic conditions required to perform deferred tests

Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

**Chapter 4 (CE)  
System Commissioning**

- C408.2.4.1 Acceptance of report
  - Buildings or portions shall not pass the final mechanical inspection until the code official has received a letter from the building owner that the Preliminary Commissioning Report has been received
- C408.2.4.2 Copy of report
  - Code official may require a copy of the report

**Chapter 4 (CE)  
System Commissioning**

- C408.2.5 Documentation requirements
  - Provided to the owner within 90 days of the date of the receipt of the certificate of occupancy
- C408.2.5.1 Drawings
  - Construction documents that include location and performance data on each piece of equipment

**Chapter 4 (CE)  
System Commissioning**

- C408.2.5.2 Manuals
  - Submittal data for each piece of equipment requiring maintenance
    - Equipment size and selected options
    - Manufacturer's operation manuals and maintenance manuals
      - Routine maintenance actions shall be clearly identified
      - Except equipment not furnished as part of the project
  - Name and address of at least one service agency
  - HVAC controls system maintenance and calibration information
    - Desired or field-determined setpoints permanently recorded
  - A written narrative on how each system is to operate including recommended setpoints

**Chapter 4 (CE)  
System Commissioning**

- C408.2.5.3 System balancing report
  - Written report describing activities completed in accordance with C408.2.2
- Final commissioning report
  - Report of test procedures and results, labeled "Final Commissioning Report" including
    - Functional performance tests results
    - Disposition of deficiencies found during testing including details of corrective measures used or proposed
    - Functional performance test procedures used, including measurable criteria for test acceptance
  - Exception - deferred tests due to climatic conditions

**Chapter 4 (CE)  
System Commissioning - Lighting**

- C408.3.1 Functional testing
  - Ensure that control hardware and software are calibrated, adjusted, programmed and in proper working order in accordance with construction documents and manufacturer's installation instructions
  - State party who will be conducting testing
    - Approved third party, when required by the building official
    - Provide documentation certifying that the controls meet the provisions of Section C405

**Chapter 4 (CE)  
System Commissioning - Lighting**

- C408.3.1 Functional testing
  - Confirm the following on occupant sensors, programmable schedule controls, photosensors or daylighting controls
    - Placement, sensitivity and time-out adjustments yield acceptable performance
    - Time switches and programmable schedule controls are programmed to turn the lights off
    - Placement and sensitivity adjustments for photosensor controls reduce the electric light based on the amount of usable daylight in the space

Figure 39: Presentation –TERP Stakeholder's Meeting, July 2012 (Continued)



### Chapter 5 (CE) Referenced Standards

- ANSI/ASHRAE/IESNA 90.2 - 2010

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### 92 Overview - Residential

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### Chapter 1 (RE) Scope and Administration

- R101.2 Scope
  - Applies to Residential buildings
- R101.3 - Intent
  - Added - over the useful life of each building
- R106.1 - Referenced codes and standards
  - Adds two subsections and clarifies when standards are to be considered
    - R106.1.1 Conflicts
    - R106.1.2 Provision in referenced codes and standards

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### Chapter 2 (RE) Definitions

- Revised definitions
  - Buildings - added - including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building
  - Residential Building - rewritten - For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses), as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane
  - Skylight - changed measurement from a slope of 15 degrees or more from vertical to 60 degrees or less from horizontal.

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### Chapter 2 (RE) Definitions

- New definitions
  - Building Site
  - Continuous Air Barrier
  - Demand Recirculation Water System
  - Fenestration Product, Site-Built
  - Visible Transmittance (VT)
  - Whole House Mechanical Ventilation System

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### Chapter 3 (RE) General Requirements

- Revised R303.1.3 Fenestration product rating
  - Added Visible Transmittance (VT) to the NFRC 200

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.5
VT	0.6	0.3	0.6	0.3	0.6

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



## Chapter 4 (RE) Residential Energy Efficiency

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- R401.2 Compliance - simplified
  - Projects shall comply with Sections identified as "mandatory" and with either sections identified as "prescriptive" or the performance approach in Section R405
- R401.3 Certificate
  - Added provisions to include - the results from any required duct system and building envelope air leakage testing done on the building

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## Chapter 4 (RE) - Table R402.1.1

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TABLE R402.1.1  
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME U-FACTOR	MASS WALL U-FACTOR	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRANK U-FACTOR
1	0.30	0.25	0.035	0.035	0.035	0.035	0.035	0.035
2	0.40	0.35	0.035	0.035	0.035	0.035	0.035	0.035
3	0.45	0.40	0.035	0.035	0.035	0.035	0.035	0.035
4 through 6	0.50	0.45	0.035	0.035	0.035	0.035	0.035	0.035
7 and 8	0.55	0.50	0.035	0.035	0.035	0.035	0.035	0.035

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## Chapter 4 (RE) Table R402.1.3

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TABLE R402.1.3  
EQUIVALENT FACTORS

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME U-FACTOR	MASS WALL U-FACTOR	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRANK U-FACTOR
1	0.30	0.25	0.035	0.035	0.035	0.035	0.035	0.035
2	0.40	0.35	0.035	0.035	0.035	0.035	0.035	0.035
3	0.45	0.40	0.035	0.035	0.035	0.035	0.035	0.035
4 through 6	0.50	0.45	0.035	0.035	0.035	0.035	0.035	0.035
7 and 8	0.55	0.50	0.035	0.035	0.035	0.035	0.035	0.035

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## Chapter 4 (RE) Building Thermal Envelope

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- R402.2.3 Eave baffle
  - For air permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.

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## Chapter 4 (RE) Table R402.2.6

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- R402.2.6 Steel-frame ceilings, walls, and floors

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## Chapter 4 (RE) Building Thermal Envelope

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- R402.2.12 Sunroom insulation (reorganized)
  - All sunrooms must meet the insulation requirements of this chapter
  - Exceptions - with thermal isolation
    - Minimum ceiling insulation R-values remain the same
    - Minimum Wall R-values remain the same
    - New walls separating the sunroom with a thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

### Chapter 4 (RE) Building Thermal Envelope

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- R402.2.3.5 Sunroom *U*-factor
  - All sunrooms enclosing conditioned space must meet the fenestration requirements of this chapter
  - Exception - sunrooms with thermal isolation and enclosing conditioned space
    - Climate Zones 4 - 8
      - Maximum *U*-factor 0.45
      - Maximum skylight *U*-factor 0.70
  - New fenestration separating the sunroom from the conditioned space shall meet the building thermal envelope requirements

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### Chapter 4 (RE) Air Leakage

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- R402.4 Air leakage
  - R402.4.1 Building thermal envelope shall comply with Sections R402.4.1.1 and R402.4.1.2.
    - The sealing methods between dissimilar material shall allow for differential expansion and contraction
    - Removed - the itemized list of where to caulk, gasket, weatherstrip or otherwise seal with an air barrier material, suitable film or solid material

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### Chapter 4 (RE) Building Thermal Envelope

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- R402.4.1.1 Installation. The components of the building thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of construction
  - Where required by the code official, an approved third party shall inspect all components and verify compliance

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### Chapter 4 (RE) Table R402.4.1.1

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Component	Installation Criteria
Exterior walls	Exterior walls shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Roofs	Roofs shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Floors	Floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Basement walls	Basement walls shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Basement floors	Basement floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Attic floors	Attic floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Garage floors	Garage floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Stairwells	Stairwells shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Interior walls	Interior walls shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Interior floors	Interior floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Basement walls	Basement walls shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Basement floors	Basement floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Attic floors	Attic floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Garage floors	Garage floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Stairwells	Stairwells shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Interior walls	Interior walls shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.
Interior floors	Interior floors shall be constructed of masonry, concrete, or other material having a minimum thermal resistance of 15.0 h·ft <sup>2</sup> ·°F/Btu (1.50 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 1 through 3 and 20.0 h·ft <sup>2</sup> ·°F/Btu (2.00 m <sup>2</sup> ·°F·h/Btu) for Climate Zones 4 through 8.

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### Chapter 4 (RE) Air Leakage

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- R402.4.1.2 Testing
  - The building or dwelling unit shall be tested with a blower door at a pressure of 0.2 w.g. (50 Pa) and verified as having an air leakage rate of not exceeding
    - 5 air changes per hour - Climate Zones 1 and 2
    - 3 air changes per hour - Climate Zones 3 through 8
  - Where required by the code official, testing shall be conducted by an approved third party
  - A written report of the results shall be signed by the party conducting the test and provided to the code official

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### Chapter 4 (RE) Air Leakage

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- R402.4.1.2 Testing shall be performed at any time after the creating of all penetrations of the building thermal envelope. During testing:
  - Exterior windows and doors shall be closed, but not sealed, beyond the intended weatherstripping or other infiltration control measures;
  - Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;
  - Interior doors, if installed at the time of the test, shall be open
  - Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
  - Heating and cooling systems, if installed at the time of the test, shall be turned off; and
  - Supply and return registers, if installed at the time of the test, shall be fully open
- R402.4.2.2 Visual inspection option


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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

### Chapter 4 (RE) Air Leakage

108

- R402.4.2 Fireplaces. New wood-burning fireplaces shall have tight-fitting flue dampers and outdoor combustion air




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### Chapter 4 (RE) Air Leakage

110

- R402.4.4 Recessed lighting
  - Removed wording - having an air leakage rate not more than 2.0 cfm of air movement from the conditioned space to the ceiling cavity



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### Chapter 4 (RE) Systems

112

- R403.2.2 Duct Sealing
- Added Exceptions
  - Air-impermeable spray foam permitted without additional joint seals
  - For a duct connection that is partially inaccessible
    - Three screws equally spaced on the exposed portion of the joint so as to prevent a hinge effect
  - Continuously welded and locking-type longitudinal joints and seams
    - Ducts operation at static pressures less than 2" w.g. (500 Pa)

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### Chapter 4 (RE) Systems

112

- R403.2.2 Duct Sealing
  - Post-Construction test
    - Removed Leakage to outdoors test
    - Changed leakage rate from 12 cfm to 4 cfm, with air handler
  - Rough-in test
    - Changed leakage rate
      - Total leakage from 6 cfm to 4 cfm, with air handler
      - Total leakage from 4 cfm to 3 cfm, without air handler
  - Exception changed
    - Air handler and ducts located entirely within the building thermal envelope

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### Chapter 4 (RE) Systems

113

- R403.2.2.1 Sealed air handler (new)
  - Manufacturer's designation for air leakage of no more than 2% of the design flow rate required
    - ASHRAE 193
- R403.2.3 Use of building cavities as ducts or plenums prohibited

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### Chapter 4 (RE) Systems

114

- R403.3.1 Protection of piping insulation (new)
  - Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance, and wind, and shall provide shielding from solar radiation that can cause degradation of the material
  - Adhesive tape shall not be permitted

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)

### Chapter 4 (RE) Systems

110

- R403.4 Service hot water systems
  - R403.4.1 Circulating hot water systems
    - Removed insulation requirements
  - R403.4.2 Hot water pipe insulation (Prescriptive) (new)
    - R3 required on piping
      - Larger than 1/2" diameter
      - Serving more than one dwelling unit
      - From the water heater to kitchen outlets
      - Located outside the conditioned space
      - From the water heater to a distribution manifold
      - Located under a floor slab
      - Buried
      - Recirculation systems except demand recirculation system
      - Run lengths greater than the maximum in Table R403.4.2

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### Chapter 4 (RE) Systems

111

- R403.5 Mechanical ventilation
  - Meets IRC or IMC or other approved means
- R403.5.1 Whole-house mechanical ventilation system fan efficacy (new)
  - Meet efficacy requirements of Table R403.5.1
  - Exception - fans integral to HVAC equipment

FAN LOCATION	AIR FLOW RATE (MINIMUM)	MINIMUM EFFICACY (%)	AIR FLOW RATE (MAXIMUM)
Range Hoods	Any	1.0 cfm/watt	Any
Bath Fan	Any	2.0 cfm/watt	Any
Bedrooms, living rooms	10	1.0 cfm/watt	< 100
Bedrooms, living rooms	10	2.0 cfm/watt	Any

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### Chapter 4 (RE) Systems

112

- R403.6 Equipment Sizing
  - Sized in accordance with ACCA Manual S
  - Based on loads calculated with ACCA Manual J

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### Chapter 4 (RE) Systems

113

- R403.9 Pools and inground permanently installed spas
  - R403.9.1 Heaters
    - On-off switch to be mounted outside of the heater
  - R403.9.2 Time switches
    - Heaters, pumps and motors with built in times shall be deemed in compliance
  - R403.9.3 Covers
    - Added inground permanently installed spas
    - Removed R-value requirements for pools heated to more than 90°F

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### Chapter 4 (RE) Electrical Power and Lighting

114

- R404.1 Lighting equipment
  - Increased minimum of high-efficacy lamps to 75%
  - Added exception for low-voltage lighting
  - Added R404.1.1 Lighting equipment
    - Fuel gas lighting systems shall not have continuously burning pilot lights

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Figure 39: Presentation –TERP Stakeholder’s Meeting, July 2012 (Continued)



## Presentation –TERP Stakeholder’s Meeting, August 2012

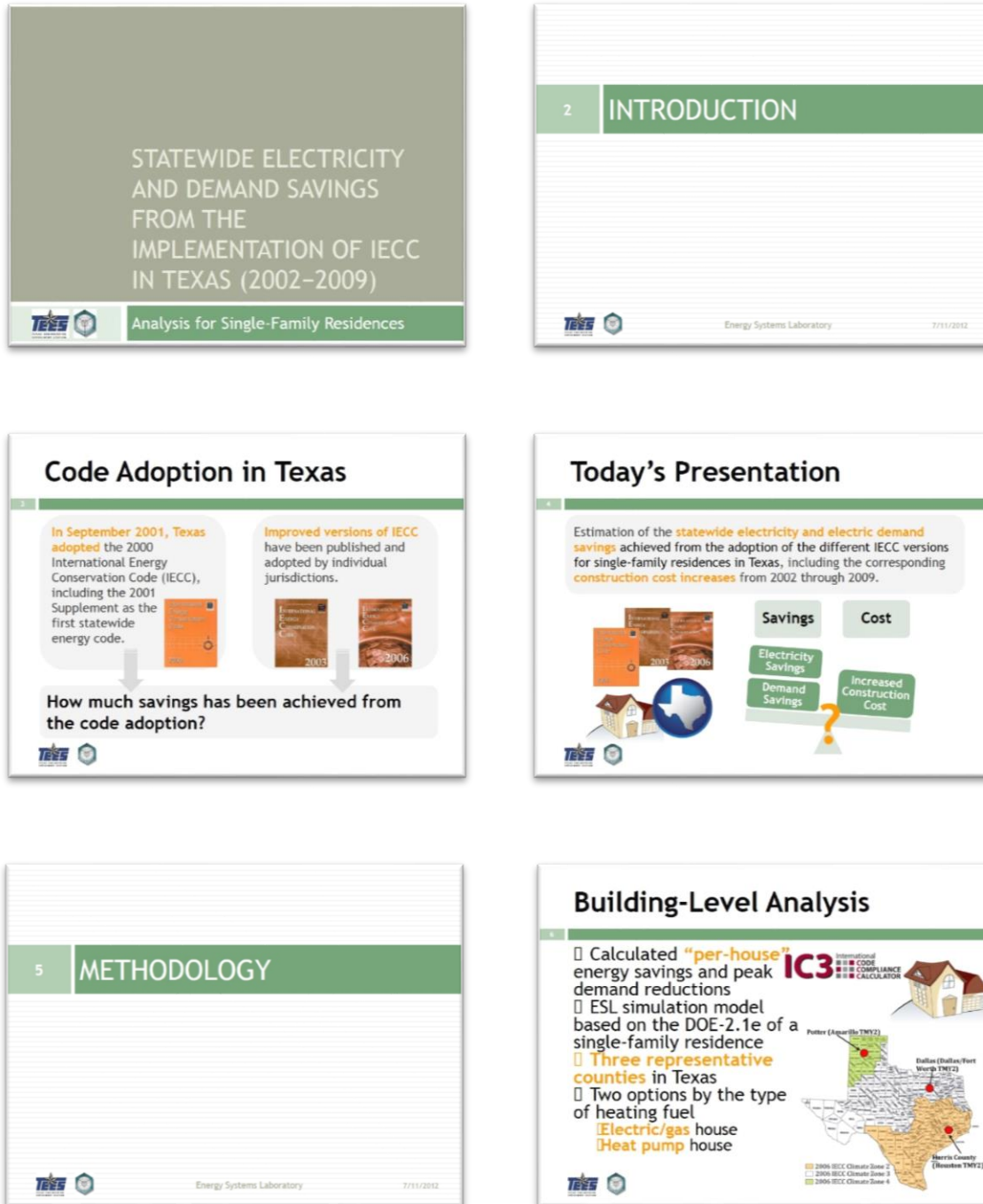


Figure 40: Presentation –TERP Stakeholder’s Meeting, August 2012 (Continued)



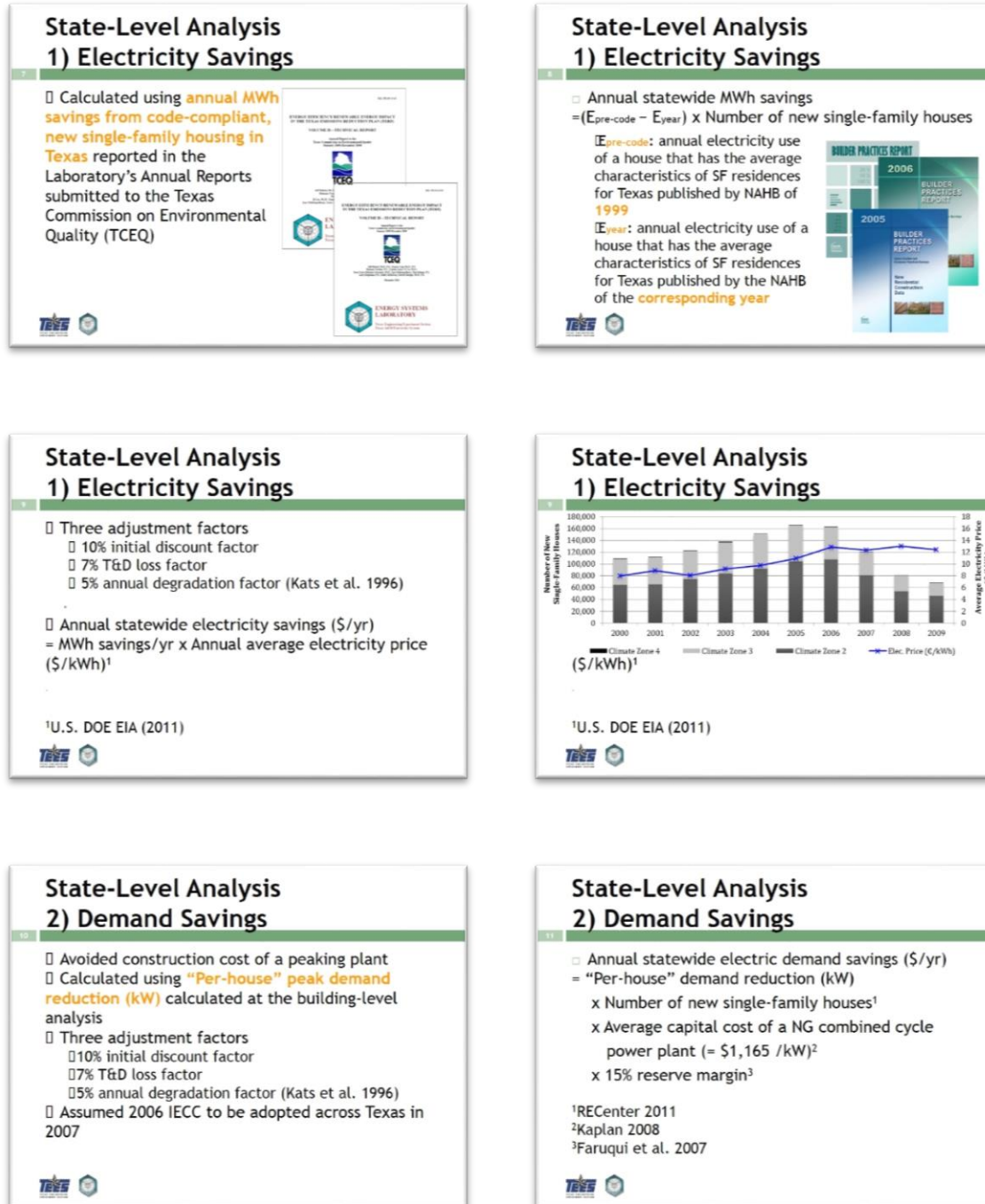


Figure 40: Presentation –TERP Stakeholder’s Meeting, August 2012 (Continued)

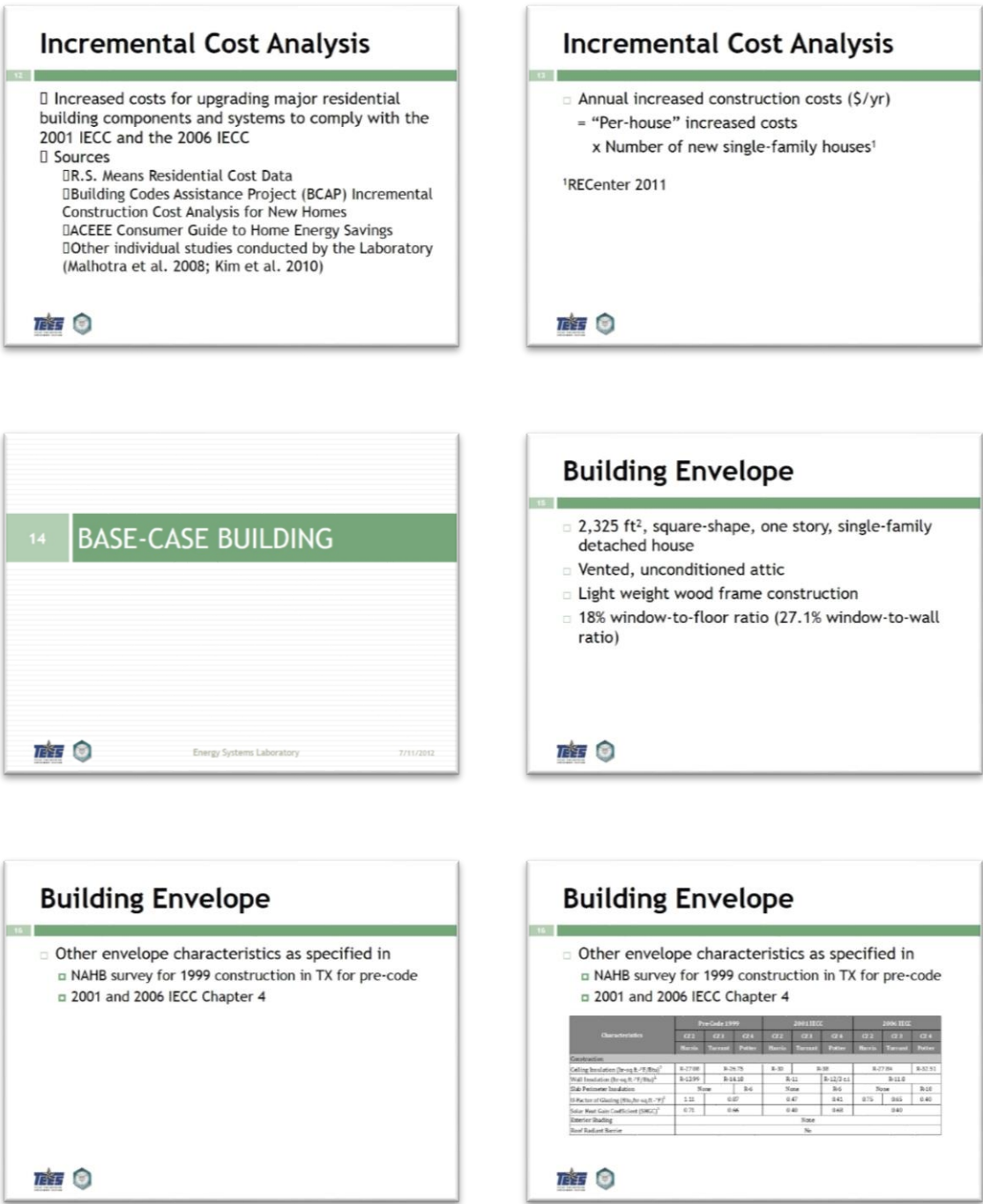


Figure 40: Presentation –TERP Stakeholder’s Meeting, August 2012 (Continued)

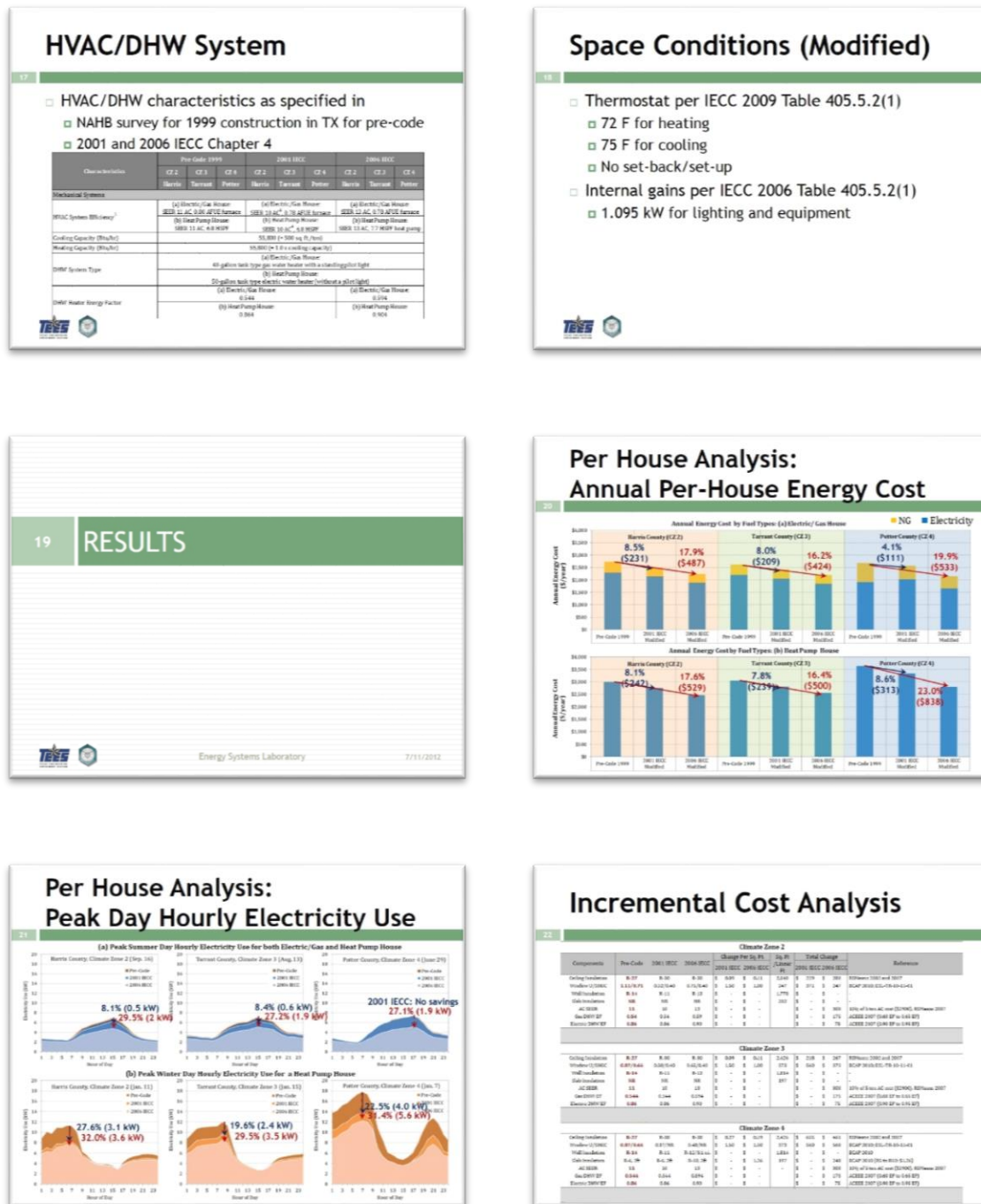


Figure 40: Presentation –TERP Stakeholder’s Meeting, August 2012 (Continued)

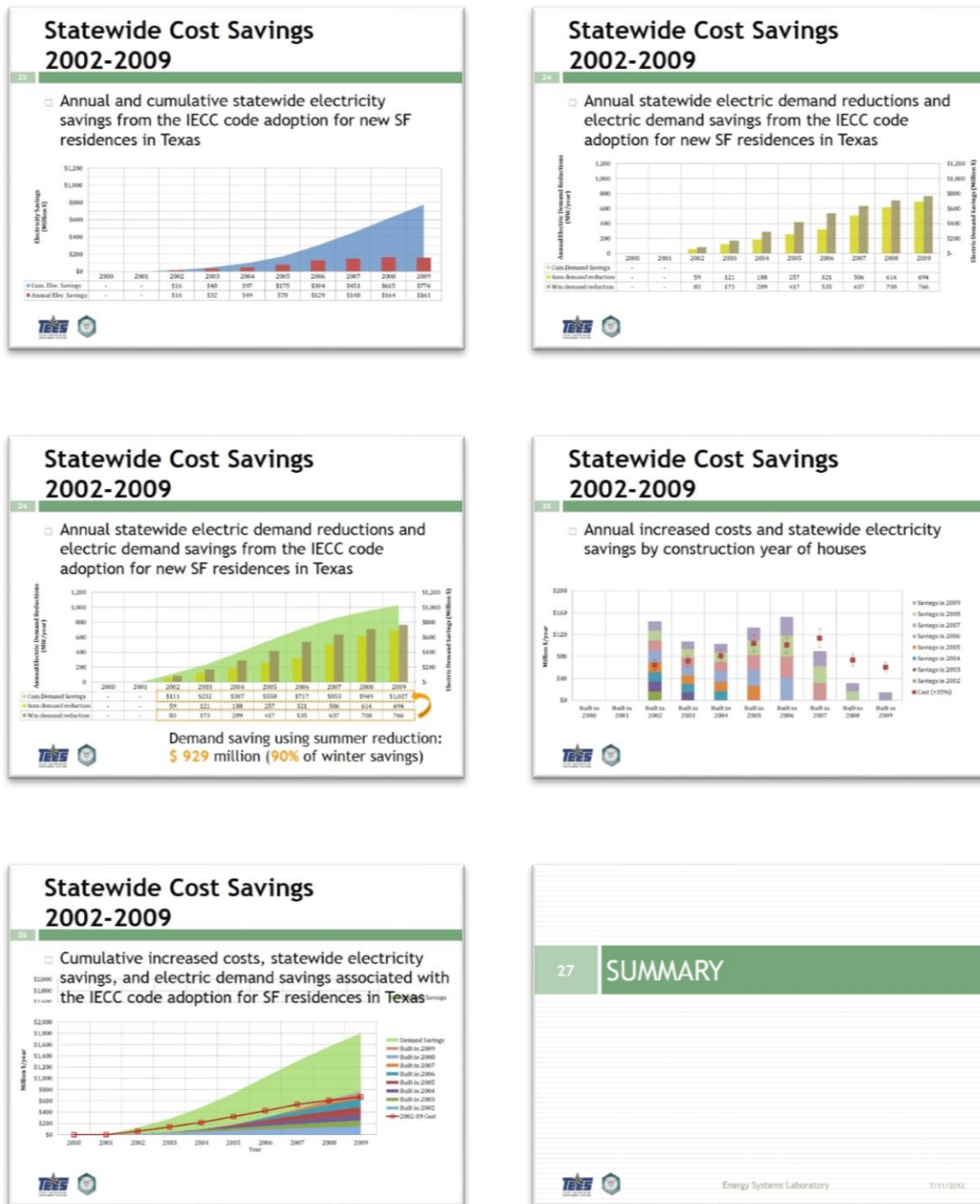


Figure 40: Presentation –TERP Stakeholder’s Meeting, August 2012 (Continued)

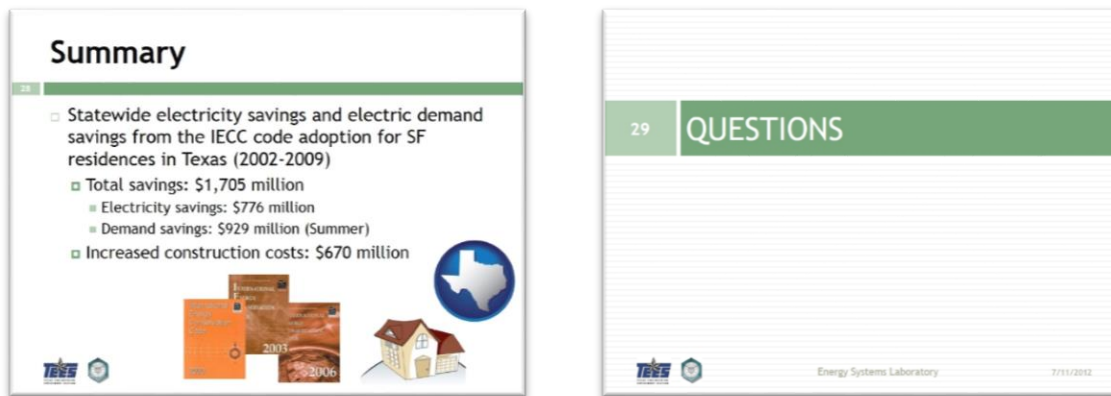


Figure 40: Presentation –TERP Stakeholder’s Meeting, August 2012 (Continued)



Presentation to IBPSA, August 2012



Figure 41: Presentation to IBPSA, August 2012

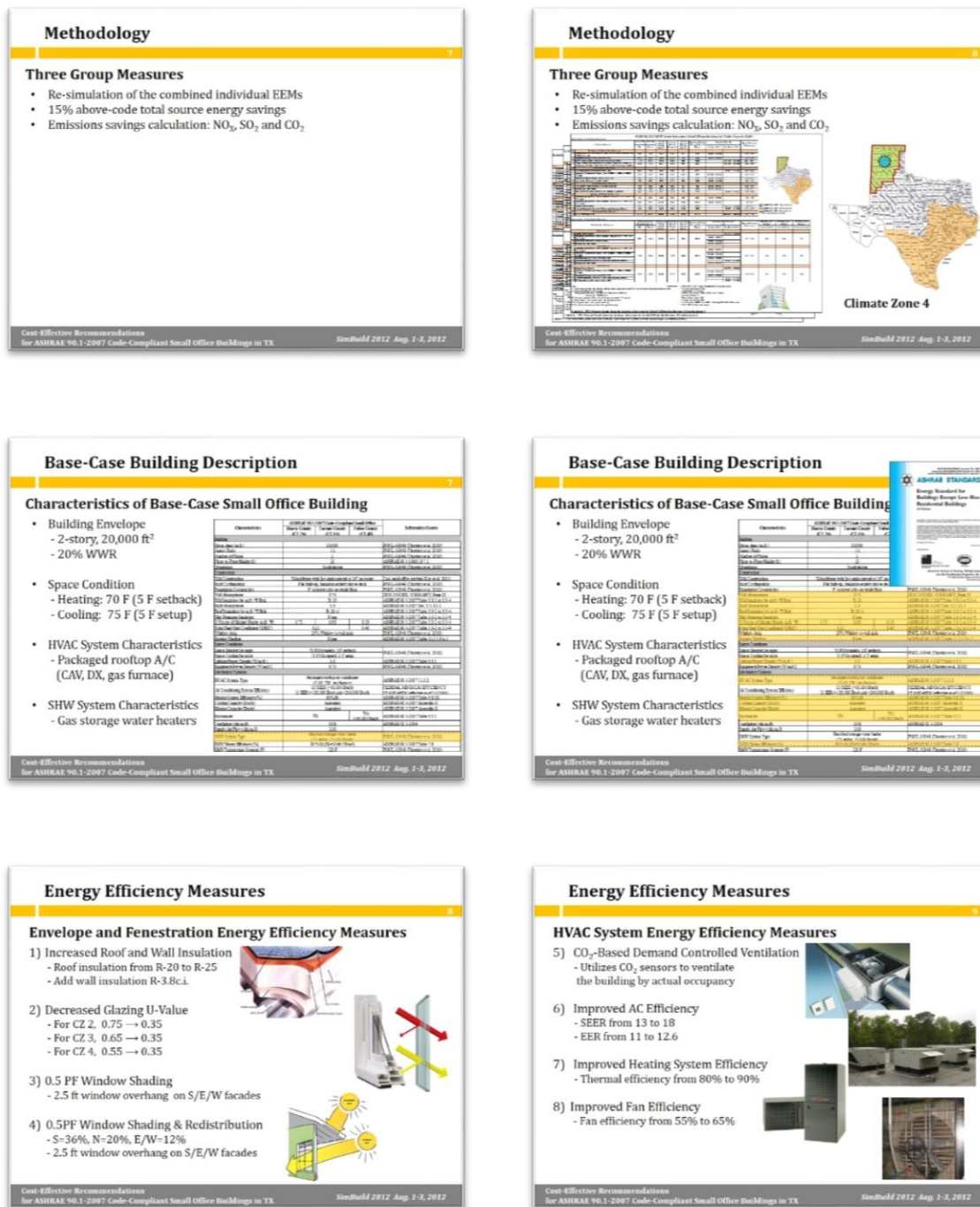



Figure 41: Presentation to IBPSA, August 2012 (continued)

### Energy Efficiency Measures

#### SHW Energy Efficiency Measures

- 9) Improved SHW Heater Efficiency
  - Thermal efficiency from 80% to 95%
- 10) Tankless Gas Water Heater
  - Standby losses from 2.4% to 0.3%
  - Minimize pump electricity use
- 11) Solar SHW System
  - Two 32 sq.ft. flat plate solar collectors
  - Additional electricity use for pump



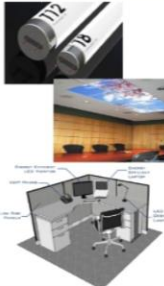
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SimBuild 2012 Aug. 1-3, 2012

### Energy Efficiency Measures

#### Lighting and Receptacles Measures

- 12) Decreased LPD to 0.9 W/sq.ft.
  - Based on the ASHRAE Standard 90.1-2010
- 13) Decreased LPD to 0.75 W/sq.ft.
  - Based on the AEDG-SMO (2011)
- 14) Daylight Dimming Controls
  - Adjust lighting levels by the level of daylight detected using photo sensors
- 15) Automatic Receptacle Control
  - Modify schedule for the plug load equipment (Based on ASHRAE Standard 90.1 - 2010)



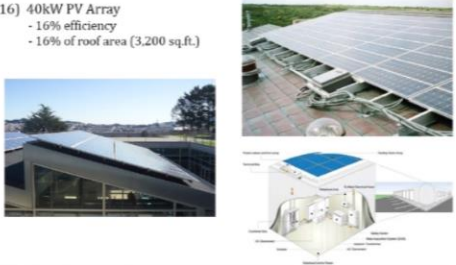
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### Energy Efficiency Measures

#### Renewable Power Measures

- 16) 40kW PV Array
  - 16% efficiency
  - 16% of roof area (3,200 sq.ft.)



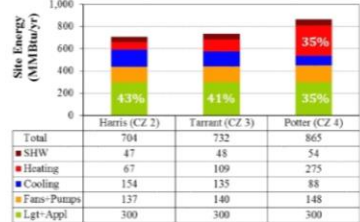
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### Results: Base-Case Energy Use

#### Site Energy Use by End Use

- High lighting & equipment energy consumption for all counties
- High heating consumption for Potter County



	Harris (CZ 2)	Tarrant (CZ 3)	Potter (CZ 4)
Total	704	732	865
SHW	47	48	54
Heating	67	109	275
Cooling	154	135	88
Fans+Pumps	137	140	148
Lgt+Appl	300	300	300

Cost-Effective Recommendations  
for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX

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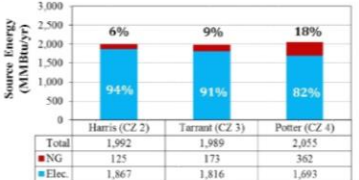
### Results: Base-Case Energy Use

#### Site Energy Use by End Use

- High lighting & equipment energy consumption for all counties
- High heating consumption for Potter County

#### Source Energy Use by Fuel Type

- Multipliers 3.16 for electricity (blue bar) and 1.1 for natural gas (red bar)





	Harris (CZ 2)	Tarrant (CZ 3)	Potter (CZ 4)
Total	1,992	1,989	2,055
NG	125	173	362
Elec	1,867	1,816	1,693

Cost-Effective Recommendations  
for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX

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### Results: Recommendations for CZ 2, CZ 3, and CZ 4

Climate Zone 4

Cost-Effective Recommendations  
for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX

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Figure 41: Presentation to IBPSA, August 2012 (continued)





Figure 41: Presentation to IBPSA, August 2012 (continued)

Results: Energy Savings from EEMs							
Annual Total Energy Savings (%) Above Base Case							
EEM #	Individual EEMs	Harris County (CZ2)		Tarrant County (CZ3)		Potter County (CZ4)	
		Site	Source	Site	Source	Site	Source
A Envelope and Fenestration Measures							
1	Increased Roof and Wall Insulation	1.2%	0.6%	1.7%	0.9%	2.9%	1.5%
2	Decreased Glazing U-Value	3.5%	1.0%	4.5%	1.5%	5.9%	2.6%
3	0.5 PF Window Shading	0.8%	1.3%	0.1%	0.9%	-1.1%	0.7%
4	Window Shading and Redistribution	1.2%	1.5%	0.6%	1.1%	-0.4%	1.1%
B HVAC System Measures							
5	CO <sub>2</sub> Based DCV	2.1%		High site and source energy savings for CZ 2 and CZ 3			
6	Improved Air Conditioner Efficiency	4.2%	4.7%	3.6%	4.2%	2.1%	2.7%
7	Improved Heating System Efficiency	1.1%	0.4%	1.7%	0.7%	3.5%	1.6%
8	Improved Fan Efficiency	2.9%	3.6%	2.4%	3.4%	1.3%	3.0%
Cost-Effective Recommendations for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX							
SimBuild 2012 Aug. 1-3, 2012							

Results: Energy Savings from EEMs							
Annual Total Energy Savings (%) Above Base Case							
EEM #	Individual EEMs	Harris County (CZ2)		Tarrant County (CZ3)		Potter County (CZ4)	
		Site	Source	Site	Source	Site	Source
A Envelope and Fenestration Measures							
1	Increased Roof and Wall Insulation	1.2%	0.6%	1.7%	0.9%	2.9%	1.5%
2	Decreased Glazing U-Value	3.5%	1.0%	4.5%	1.5%	5.9%	2.6%
3	0.5 PF Window Shading	0.8%	1.3%	0.1%	0.9%	-1.1%	0.7%
4	Window Shading and Redistribution	1.2%	1.5%	0.6%	1.1%	-0.4%	1.1%
B HVAC System Measures							
5	CO <sub>2</sub> Based DCV	2.1%	1.6%	2.0%	1.2%	3.2%	1.6%
6	Improved Air Conditioner Efficiency	4.2%	4.7%	3.6%	Good savings potential		
7	Improved Heating System Efficiency	1.1%	0.4%	1.7%			
8	Improved Fan Efficiency	2.9%	3.6%	2.4%	3.4%	1.3%	3.0%
Cost-Effective Recommendations for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX							
SimBuild 2012 Aug. 1-3, 2012							

Results: Energy Savings from EEMs							
Annual Total Energy Savings (%) Above Base Case							
EEM #	Individual EEMs	Harris County (CZ2)		Tarrant County (CZ3)		Potter County (CZ4)	
		Site	Source	Site	Source	Site	Source
<b>C Service Hot Water Measures</b>							
9	Improved SHW Heater Efficiency	1.1%	0.4%	1.0%	0.4%	1.0%	0.5%
10	Tankless Gas Water Heater	1.8%	1.6%	1.8%	1.6%	1.6%	1.6%
11	Solar Service Hot Water System	3.3%	1.2%	3.6%	1.4%	3.2%	1.4%
<b>D Lighting and Receptacles Measures</b>							
12	Decreased LPD to 0.9 W/sq.ft.	2.3%	2.8%	1.9%	2.6%	1.2%	2.3%
13	Decreased LPD to 0.75W/sq.ft.	5.7%	7.0%	4.8%	6.6%	3.0%	5.7%
14	Daylight Dimming Controls	6.5%	7.8%	5.7%	7.5%	4.1%	6.8%
15	Automatic Receptacle Control	2.3%	2.7%	1.9%	2.6%	1.3%	2.3%
<b>E Renewable Power Measures</b>							
16	40 kW Photovoltaic Array	20.6%	23.1%	29.3%	34.1%	27.1%	36.1%
Cost-Effective Recommendations for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX							
SimBuild 2012, Aug. 1-3, 2012							

Results: Energy Savings from EEMs							
Annual Total Energy Savings (%) Above Base Case							
EEM #	Individual EEMs	Harris County (CZ2)		Tarrant County (CZ3)		Potter County (CZ4)	
		Site	Source	Site	Source	Site	Source
<b>C Service Hot Water Measures</b>							
9	Improved SHW Heater Efficiency	1.1%	0.4%	1.0%		High site energy savings	
10	Tankless Gas Water Heater	1.8%	1.6%	1.8%			
11	Solar Service Hot Water System	3.3%	1.2%	3.6%	1.4%	3.2%	1.4%
<b>D Lighting and Receptacles Measures</b>							
12	Decreased LPD to 0.9 W/sq.ft.	2.3%	2.8%	1.9%	2.6%	1.2%	2.3%
13	Decreased LPD to 0.75W/sq.ft.	5.7%	7.0%	4.8%	6.6%	3.0%	5.7%
14	Daylight Dimming Controls	6.5%	7.8%	5.7%	7.5%	4.1%	6.8%
15	Automatic Receptacle Control	2.3%	2.7%	1.9%	2.6%	1.3%	2.3%
<b>E Renewable Power Measure</b>							
16	40 kW Photovoltaic Array	20.6%	23.1%	29.3%	34.1%	27.1%	36.1%
Cost-Effective Recommendations for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX							
SimBuild 2012 Aug. 1-3, 2012							

Results: Energy Savings from EEMs							
Annual Total Energy Savings (%) Above Base Case							
EEM #	Individual EEMs	Harris County (CZ2)		Tarrant County (CZ3)		Potter County (CZ4)	
		Site	Source	Site	Source	Site	Source
C Service Hot Water Measures							
9	Improved SHW Heater Efficiency	1.1%	0.4%	1.0%	0.4%	1.0%	0.5%
10	Tankless Gas Water Heater	1.8%	1.6%	1.8%	1.6%	1.6%	1.6%
11	Solar Service Hot Water System	3.3%	1.2%	3.6%	1.4%	3.2%	1.4%
D Lighting and Receptacles Measures							
12	Decreased LPD to 0.9 W/sq.ft.	2.3%	2.8%	1.9%	Considerable savings		
13	Decreased LPD to 0.75W/sq.ft.	5.7%	7.0%	4.8%	6.6%	3.0%	5.7%
14	Daylight Dimming Controls	6.5%	7.8%	5.7%	7.5%	4.1%	6.8%
15	Automatic Receptacle Control	2.3%	2.7%	1.9%	2.6%	1.3%	2.3%
E Renewable Power Measure							
16	40 kW Photovoltaic Array	20.6%	23.1%	29.3%	34.1%	27.1%	36.1%
Cost-Effective Recommendations for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX							
SimBuild 2012 Aug. 1-3, 2012							

# Results: Energy Savings from EEMs

## Annual Total Energy Savings (%) Above Base Case

EEM #	Individual EEMs	Harris County (CZ2)		Tarrant County (CZ3)		Potter County (CZ4)	
		Site	Source	Site	Source	Site	Source
C Service Hot Water Measures							
9	Improved SHW Heater Efficiency	1.1%	0.4%	1.0%	0.4%	1.0%	0.5%
10	Tankless Gas Water Heater	1.8%	1.6%	1.8%	1.6%	1.6%	1.6%
11	Solar Service Hot Water System	3.3%	1.2%	3.6%	1.4%	3.2%	1.4%
D Lighting and Receptacles Measures							
12	Decreased LPD to 0.9 W/sq.ft.	2.3%	2.8%	1.9%	2.6%	1.2%	2.3%
13	Decreased LPD to 0.75W/sq.ft.	5.7%	7.0%	4.8%	6.6%	3.0%	5.7%
14	Daylight Dimming Controls	6.5%	7.8%	5.7%	7.5%	4.1%	6.8%
15	Automatic Receptacle Control	2.3%	2.7%	1.9%	2.6%	1.3%	2.3%
E Renewable Power Measure						Largest savings	
16	40 kW Photovoltaic Array	20.6%	23.1%	29.3%	34.1%	27.1%	36.1%

Cost-Effective Recommendations for ASHRAE 90.1-2007 Code-Compliant Small Office Buildings in TX

SimBuild 2012 Aug. 1-3, 2012

Figure 41: Presentation to IBPSA, August 2012 (continued)



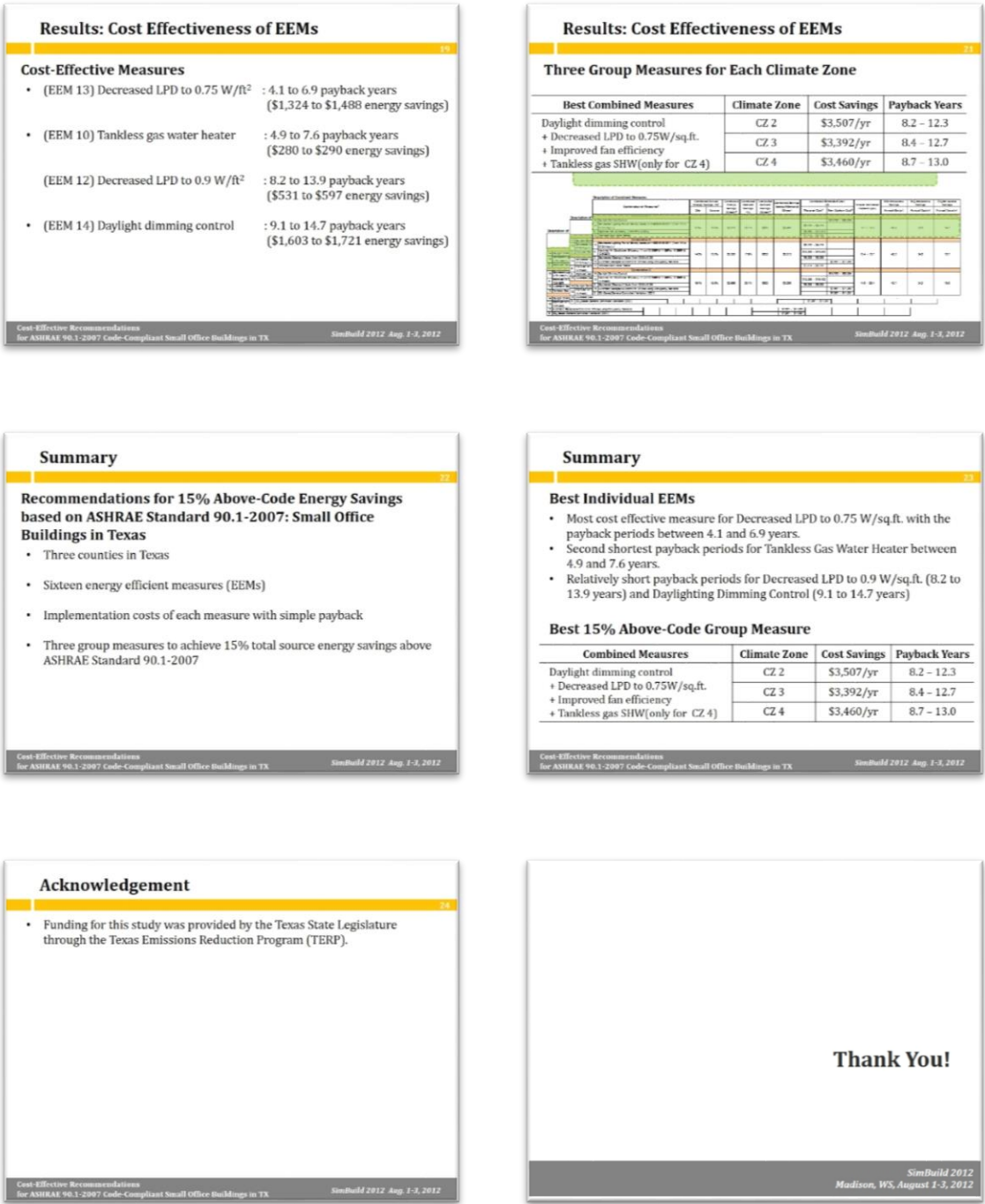


Figure 41: Presentation to IBPSA, August 2012 (continued)

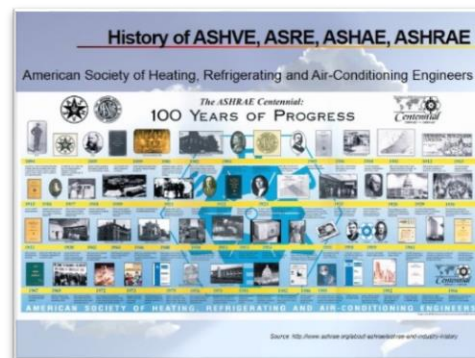
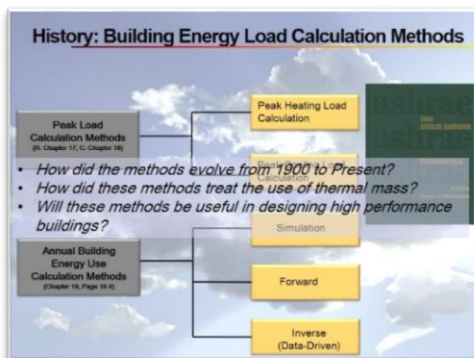
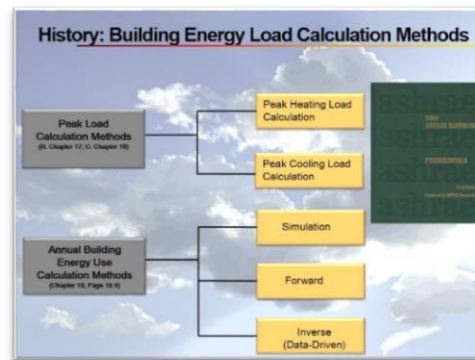
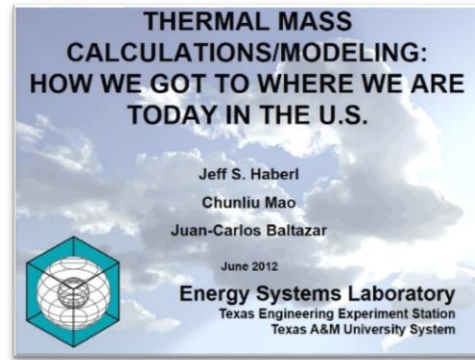


Figure 41: Presentation to IBPSA, August 2012 (continued)



Figure 41: Presentation to IBPSA, August 2012 (continued)





Figure 41: Presentation to IBPSA, August 2012 (continued)

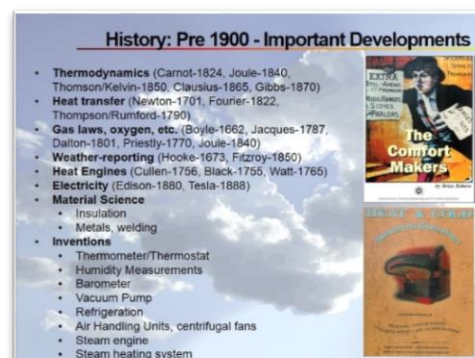
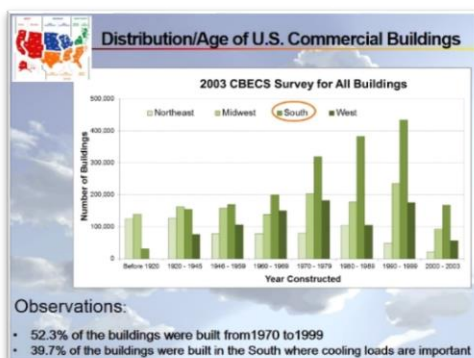
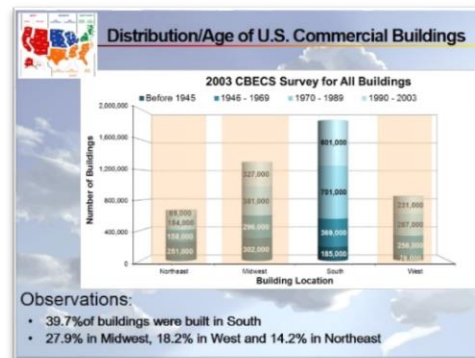
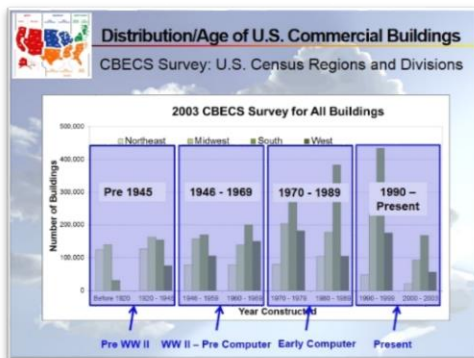
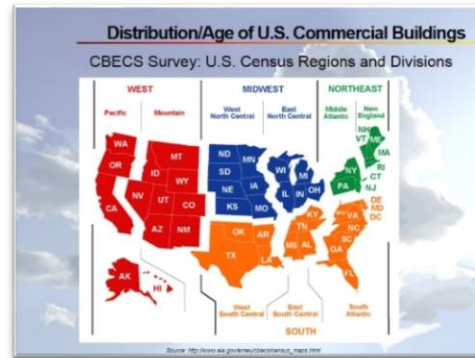
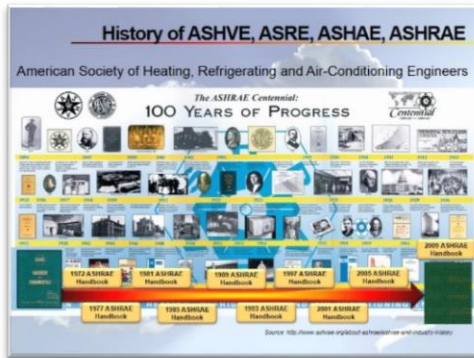


Figure 41: Presentation to IBPSA, August 2012 (continued)



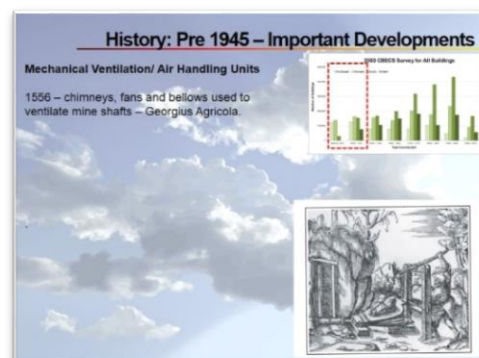
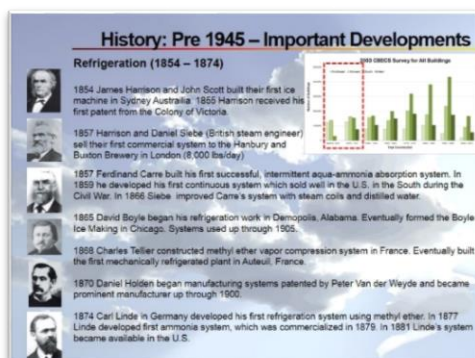
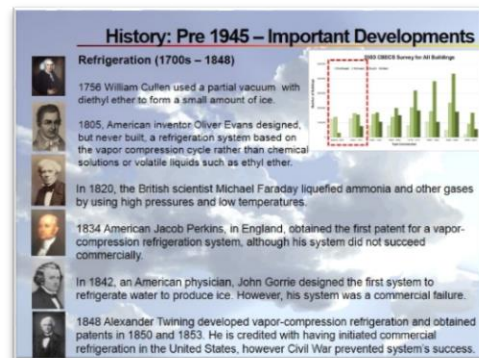
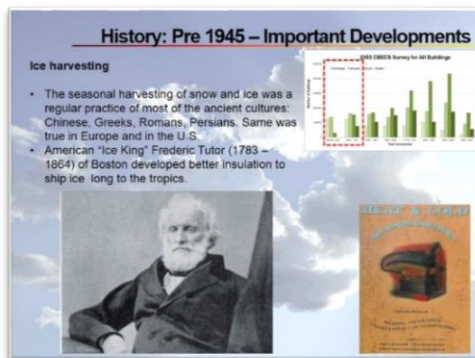
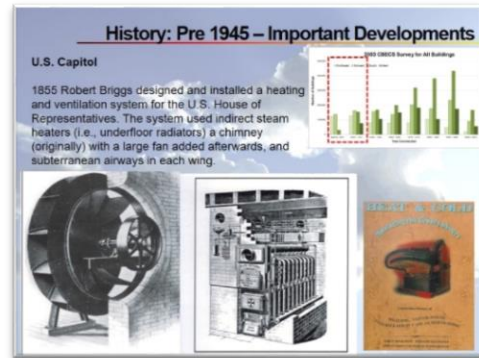
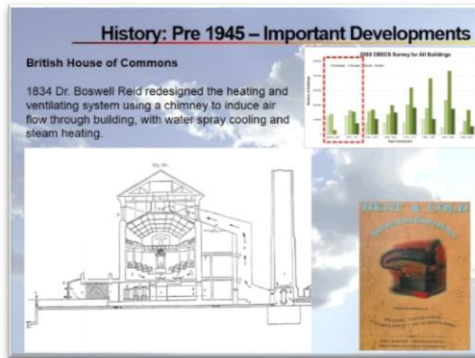


Figure 41: Presentation to IBPSA, August 2012 (continued)

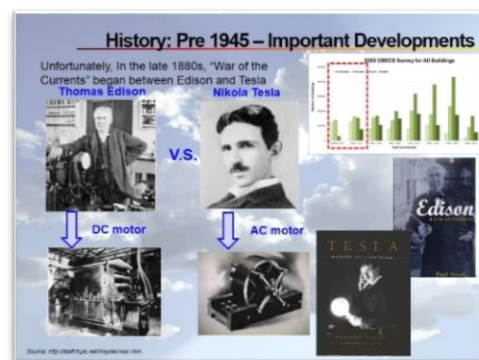
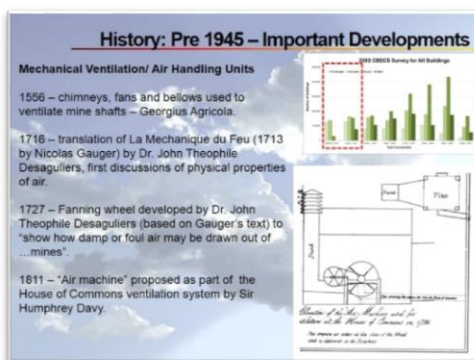
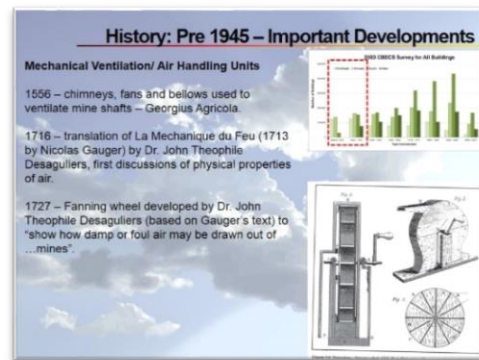
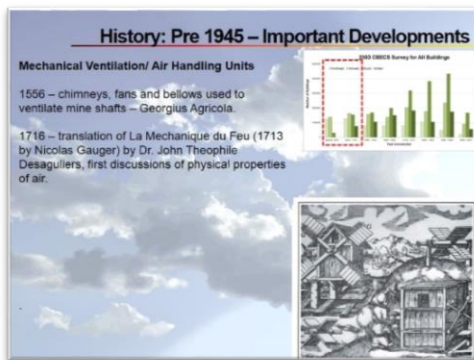
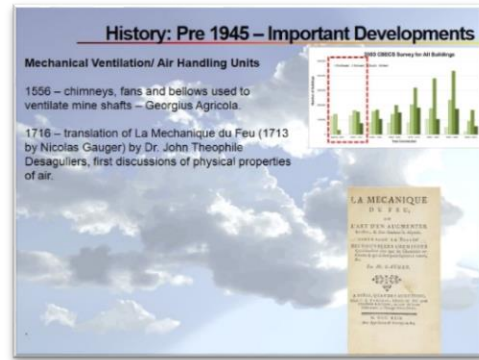
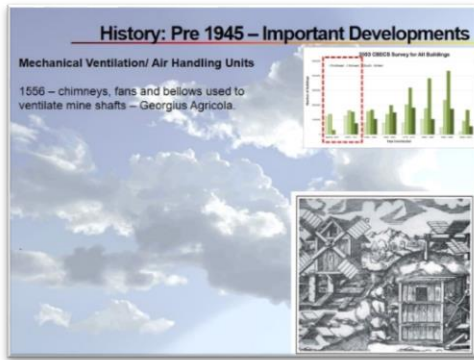


Figure 41: Presentation to IBPSA, August 2012 (continued)

### History: Pre 1945 – Important Developments

#### Mechanical Ventilation/ Air Handling Units

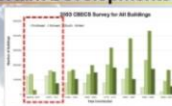

1861 Benjamin Franklin Sturtevant, originally a shoemaker, invented a cast iron pressure blower. Later combined with heater to form hot-air furnace.

1878 Charles Barlow (London) invented and patented a multi-vane fan, blades  $\frac{1}{4}$  depth of radius of the wheel.

1884 Buffalo Forge began manufacturing heating and ventilating equipment.

1901 Willis Carrier started working for Buffalo Forge as an engineer. He was assigned to the new research and development department.

1902 Carrier designed his first cooling coil air conditioning system for the Sackett & Wilhelms Co., in Brooklyn, N.Y., which was not successful.

### History: Pre 1945 – Important Developments

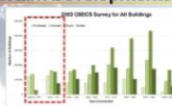
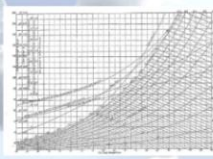
#### Mechanical Ventilation/ Air Handling Units

1902-1903 Carrier researched the failure at the Sackett & Wilhelms building in Brooklyn and determined that a spray-type air washer could be used to control the humidity.

1906 Carrier developed a working system and applied for a patent for an "apparatus for treating air", which allowed him to control the absolute humidity of the exiting air stream.

1906 Buffalo Forge began selling spray air-washers, which were first applied to industrial settings.



1908 Willis Carrier publishes his first psychrometric chart based on his psychrometric formulas.

### History: Pre 1945 – Guide Books

#### Guide & Text Books:

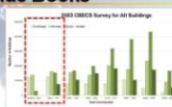

- 1893 Hermann Reitschel *Heizungs und Lüftungstechnik - Heating and Ventilation Handbook*
- 1904 Frank E. Kidder *Architect's and Builder's Handbook*
- 1914 Buffalo Forge *Engineer's Handbook*
- 1922 ASHVE Guide

### History: Pre 1945 – Guide Books

#### Guide & Text Books:


- 1932 ASRE *The Refrigerating Data Book*
- 1937 Gay and Fawcett *Mechanical and Electrical Equipment for Buildings*
- 1938 Trane *Air Conditioning Manual*

### History: Pre 1945 – Important Developments

#### Computer Development:

- 1822 - 1832, Charles Babbage and Joseph Clement produced the first Difference Engine
- 1815-1852, first computer programmer, Ada Lovelace
- In 1930, differential analyzer available
- In 1946, first large scale electronic digital computer available - ENIAC

### History: Pre 1945 – Heating Load Calculation

1904 - Frank E. Kidder *Architect's and Builder's Handbook*

- Contained useful information about all aspects of building construction, including: practical math, the metric system, geometry, strength of materials, foundations, wood and steel construction, truss design, heating and ventilation.
- In 17<sup>th</sup> edition (1904), section on heating and ventilation contained complete treatment on the calculation of heating loads, system design, etc.

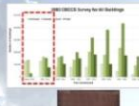
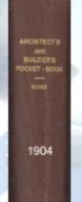



Figure 41: Presentation to IBPSA, August 2012 (continued)



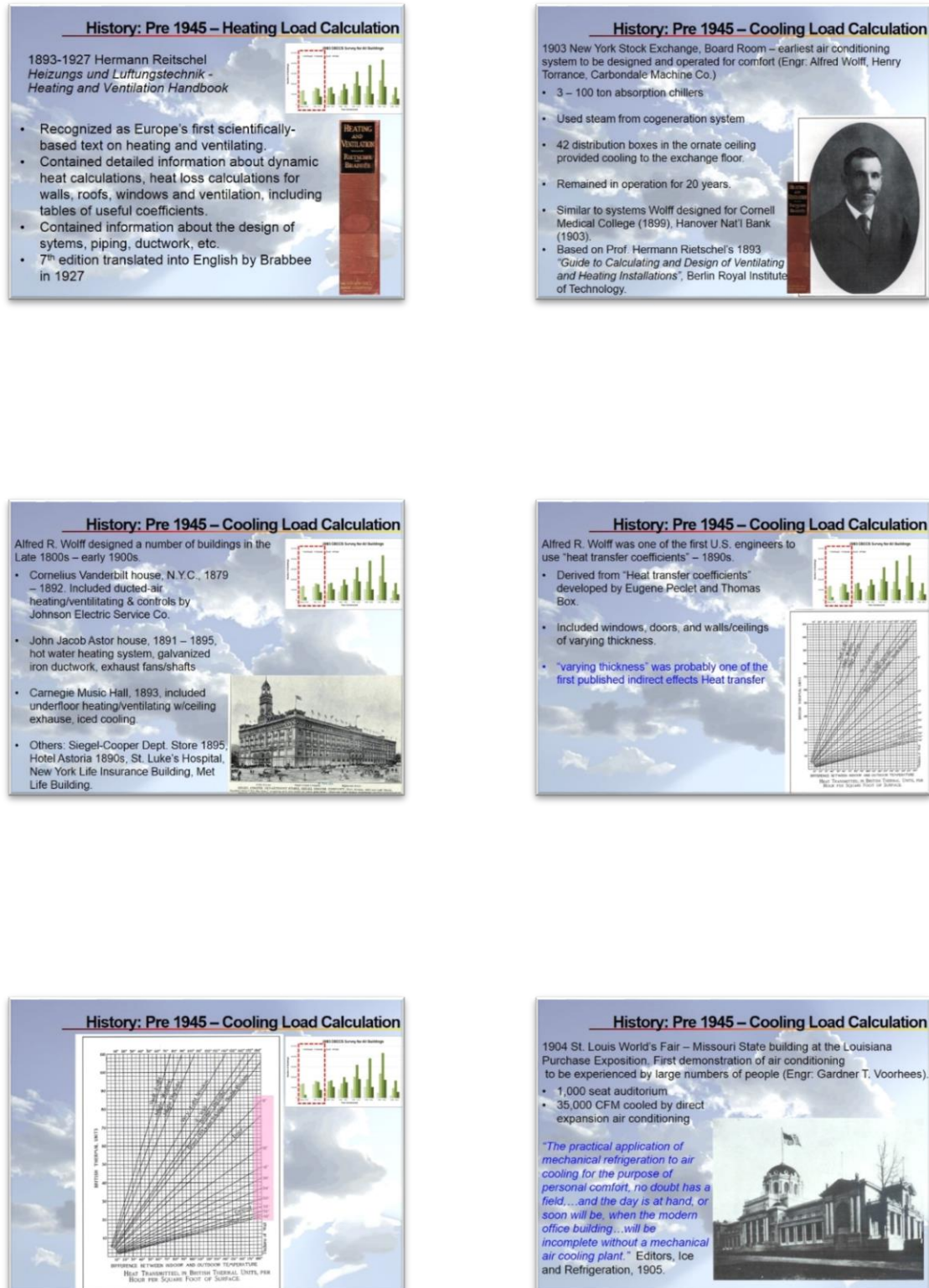


Figure 41: Presentation to IBPSA, August 2012 (continued)

### History: Pre 1945 – Heating Load Calculation

- In 1905, Stuart Cramer first used the term **"air conditioning"** for treating air in textile mills in N.C.

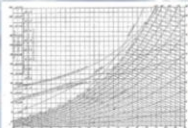



Source: Cramer, W. 1914. Rational Psychrometric Formulae, their relation to the problems of meteorology and of air conditioning. ASHVE Transactions, Vol. 22

### History: Pre 1945 – Heating Load Calculation

1914 Buffalo Forge *Engineer's Handbook*

- Contained detailed heating and ventilating calculating
- First use of Carrier's psychrometric charts in a handbook

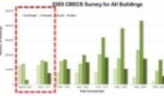

### History: Pre 1945 – Guide Books

1922 ASHVE Guide Book:

- Contained articles from ASHVE Transactions.
- Had General Data Section on "Heating", p.109
- Had basic heat loss formula "word formulas"

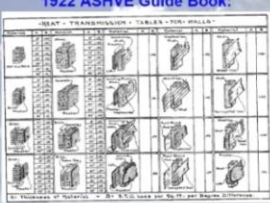
*"In the planning of a heating installation consideration must necessarily be given to the heat losses which the heating apparatus must overcome. For convenience this loss is determined in heat units in terms of B. t. u. foot per hour.*

*Heat losses from buildings can be classified as those due to the leakage of cold air into and warm air out of the building, commonly termed infiltration, as those due to transmission through the building material enclosing the building or space termed transmission losses. The total heat loss or amount of heat which the equipment must furnish is the sum of the infiltration and transmission losses plus an allowance, which should be made for exposure."*





### History: Pre 1945 – Guide Books

1922 ASHVE Guide Book:


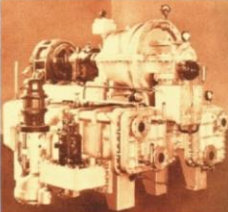


L. A. Harding submitted to the Society, in 1913, a paper entitled: Heat Losses by Transmission Through Various Building Materials (see Vol. 19 of the Transactions), from which the following table is reproduced. The data was calculated by the author and checked by experiments which reproduced the conditions existing in buildings.



### History: Pre 1945 – Cooling Load Calculation

In 1928, the first high-rise air-conditioned office building in U.S. was built in San Antonio "The Milam Building"

Source: www.asme.org/technicalresources/Milam\_Building\_Report.pdf

### History: Pre 1945 – Cooling Load Calculation

In 1928, the first high-rise air-conditioned office building in U.S. was built in San Antonio "The Milam Building"

- In 1928 - Tallest Reinforced-Concrete High-Rise Office Building, 210,651 sq ft
- Air-Conditioning System was designed by Carrier Engineering Corporation
- 11 AHUs provided cooling, thermal storage tank (chilled water).
- Two Chillers with a Maximum 375-ton Capacity provided Chilled Water: 562 sq/ton
- Radiant heat was supposed to be absorbed by the heavy construction
- Venetian blinds, cloth window shades, duct dampers were added to solve morning/afternoon overheating
- Design methods never published
- In 1930 Carrier designed installed cooling system in the U.S. Oval Office.



Source: www.asme.org/technicalresources/Milam\_Building\_Report.pdf

Figure 41: Presentation to IBPSA, August 2012 (continued)



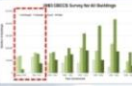

### History: Pre 1945 – Heating Load Calculation

1935 Gay and Fawcett *Mechanical and Electrical Equipment for Buildings*

- Contained *detailed calculations* for heat loss and *only rough calculations* for heat gain.

21. Heat to be Removed.—The heat to be removed in summer is considered as arising from the following sources:

(a) Transmission.—In Chap. VII it is seen that there is a flow of heat through substances from those of higher to those of lower temperature. In winter the direction of flow is from warm rooms through the walls, floors, roof and window glass to the cold outer atmosphere. In summer the normal flow is in the opposite direction from the hot outer atmosphere through to the cooler rooms. This flow will continue until the outdoor and indoor temperatures are equalized. The same coefficients of transmission are used in summer as in winter calculations, the difference between outdoor and indoor temperatures, however, being taken at not more than 15°. (See Art. 12, Cooling.)

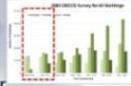




### History: Pre 1945 – Heating Load Calculation

1935 Gay and Fawcett *Mechanical and Electrical Equipment for Buildings*

- Contained *detailed calculations* for heat loss and *only rough calculations* for heat gain.

(c) Sunlight.—The radiant heating effect of direct sunlight upon walls, roofs and window glass is realized as very important but the data so far derived from study of the subject have not much practical value. At present a rule-of-thumb method of adding 25° to the dry-bulb temperature difference in calculating the heat transmission through a wall, roof or window exposed to direct sunlight for an appreciable time is generally accepted. Any shields, such as awnings, which prevent sunlight from striking directly upon glass, will greatly reduce the solar effect.

### History: Pre 1945 – Guide Books

1930s ASHRAE began to study the effects of solar radiation and heat gain through roofs (light, medium, heavy) and windows for the purpose of checking design calculations at the Pittsburgh ASHVE lab (est. 1919).


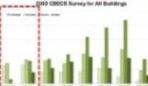



FIG. 3. TEST CHAMBER WITH THREE ROOF PANELS UNDER TEST

### History: Pre 1945 – Guide Books

- The study was to determine the "sun's effect" of different types of roofs.
- Their research showed that large errors occurred when "periodic" effects of the "sun's effect" were not properly taken into account.

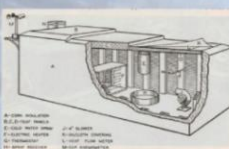
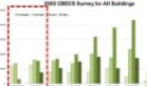



FIG. 4. THE SUNSHINE CHAMBER FOR ANALYZING HEAT FLOW THROUGH ROOF PANELS

### History: Pre 1945 – Guide Books

Test roofs were instrumented with thermocouples to record temperatures using strip chart recorders.

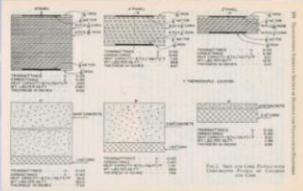




FIG. 5. TEST CHAMBER WITH THREE ROOF PANELS UNDER TEST

### History: Pre 1945 – Guide Books

- Data recorded on strip chart recorders and manual readings for later transcription.
- Published paper included complete solution to the differential equation for heat transfer through the homogeneous roof elements.




FIG. 6. TEST CHAMBER WITH THREE ROOF PANELS UNDER TEST

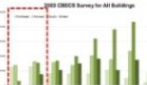

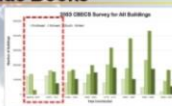



Figure 41: Presentation to IBPSA, August 2012 (continued)

### History: Pre 1945 – Guide Books

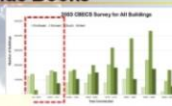
Of interest to the Houghton paper are the comments of then President Carrier:



**PRESIDENT CARRIER:** I have visualized the application of these results as very important in winter heating. We have exact coefficients of conductivity and heat transfer, but their applications do not really mean a thing excepting for thin materials having small heat capacity such as glass. With thicker walls having greater heat capacity, the varying temperature prevailing results in a maximum rate of heat penetration which is considerably lower than that calculated from data available in the past. It is necessary to use a lower rate of heat flow to compensate for the heat capacity. The application of our transmission tables or perhaps the tables themselves will have to be revised in order to give accurate rates of heat flow for every construction.

### History: Pre 1945 – Guide Books

In the 1935 paper by Faust and Urban (at GE), tables were published that quantified the "sun effect" for use in cooling calculating.




No. 1021  
**A RATIONAL HEAT GAIN METHOD FOR THE DETERMINATION OF AIR CONDITIONING COOLING LOADS**  
By F. H. FAUST\* (MEMBER), L. LEVINE\* and F. O. URBAN\* (CONMEMBER)  
Schenectady, N. Y.

**INTRODUCTION**  
SCIENTIFIC application of air conditioning equipment requires that such equipment shall have adequate capacity to maintain specified indoor conditions, but that the margin of capacity over what is required shall not be so great as to make the installation economically unprofitable. Thus, the first step in an application is to determine the maximum cooling effect which is necessary, and the second step is to select equipment which is capable of producing this required cooling effect both economically and with a degree of flexibility necessary to meet varying conditions of operation.

This paper summarizes the factors which affect the cooling load, and describes a systematic and rational method for accurately determining its character and magnitude. A brief, able calculation sheet is enclosed which, within reasonable

### History: Pre 1945 – Guide Books

Results were published as tables of heat gain coefficients for selected surfaces at specific orientations at different latitudes.



ASHRAE TRANSACTIONS AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS  
TABLE 3. SUN EFFECT COEFFICIENTS AT VARIOUS LATITUDES FOR WALLS FACING SEVERAL DIRECTIONS  
 $I$  = Btu per hour striking 1 sq ft of wall surface  
 $R_s$  = Btu per hour transmitted by 1 sq ft of single glass (the double glass multiply value of  $R_s$  given below by 0.8)

SUNSET TIME, DAY, AND MONTH	COMMENTS	TIME OF DAY	DIRECTION WALL FACES							HEAT GAIN COEFFICIENT
			NE	E	SE	S	SW	W	NW	
JULY	6 A.M.	100	105	105	105	105	105	105	105	105
		7	105	105	105	105	105	105	105	105
		8	115	105	105	105	105	105	105	105
		9	130	105	105	105	105	105	105	105
		10	105	105	105	105	105	105	105	105
		11	105	105	105	105	105	105	105	105
		12	105	105	105	105	105	105	105	105
		1	105	105	105	105	105	105	105	105
		2	105	105	105	105	105	105	105	105
		3	105	105	105	105	105	105	105	105
		4	105	105	105	105	105	105	105	105
AUG.	1 P.M.	100	105	105	105	105	105	105	105	
		7	105	105	105	105	105	105	105	105
		8	115	105	105	105	105	105	105	105
		9	130	105	105	105	105	105	105	105
		10	105	105	105	105	105	105	105	105
		11	105	105	105	105	105	105	105	105
		12	105	105	105	105	105	105	105	105
		1	105	105	105	105	105	105	105	105
		2	105	105	105	105	105	105	105	105
		3	105	105	105	105	105	105	105	105
		4	105	105	105	105	105	105	105	105

### History: Pre 1945 – Guide Books

These tables allowed for an improved cooling load calculations for surfaces at different orientations/latitudes, etc.




TABLE 5. TIME OF MAXIMUM COOLING LOAD FOR ROOFS WITH DIFFERENT EXPOSURES (To be used with Fig. 4)

Roof Number from Fig. 4	Number of Walls Exposed	Exposure of Walls	AVERAGE OF WALLS		NO AVERAGE OF WALLS	
			OUTER WALLS	ROOF ON AVERAGE	OUTER WALLS	ROOF ON AVERAGE
1	1	N	2 P.M.	2 P.M.	2 P.M.	2 P.M.
2	1	NE	2 P.M.	2 P.M.	2 P.M.	2 P.M.
3	1	E	2 P.M.	2 P.M.	2 P.M.	2 P.M.
4	1	SE	2 P.M.	2 P.M.	2 P.M.	2 P.M.
5	1	S	2 P.M.	2 P.M.	2 P.M.	2 P.M.
6	1	SW	2 P.M.	2 P.M.	2 P.M.	2 P.M.
7	1	W	2 P.M.	2 P.M.	2 P.M.	2 P.M.
8	1	NW	2 P.M.	2 P.M.	2 P.M.	2 P.M.
9	2	N E	2 P.M.	2 P.M.	2 P.M.	2 P.M.
10	2	NE SE	2 P.M.	2 P.M.	2 P.M.	2 P.M.
11	2	E SW	2 P.M.	2 P.M.	2 P.M.	2 P.M.
12	2	SE SW	2 P.M.	2 P.M.	2 P.M.	2 P.M.

### History: Pre 1945 – Guide Books

In 1933, ASHVE and PPG set up two identical "test houses" to determine the impact of single-pane glazing versus double-pane glazing.






FIG. 2. EXTENSION OF DOUBLE-GLAZED TEST HOUSE. DOUBLE-GLAZED HOUSE IDENTICAL

### History: Pre 1945 – Guide Books

Tests conducted on top of three story lab in Creighton, PA






FIG. 1. TEST HOUSES ON TOP OF THREE-STORY LABORATORY BUILDING WITH RELATION TO THEIR SURROUNDINGS

Figure 41: Presentation to IBPSA, August 2012 (continued)

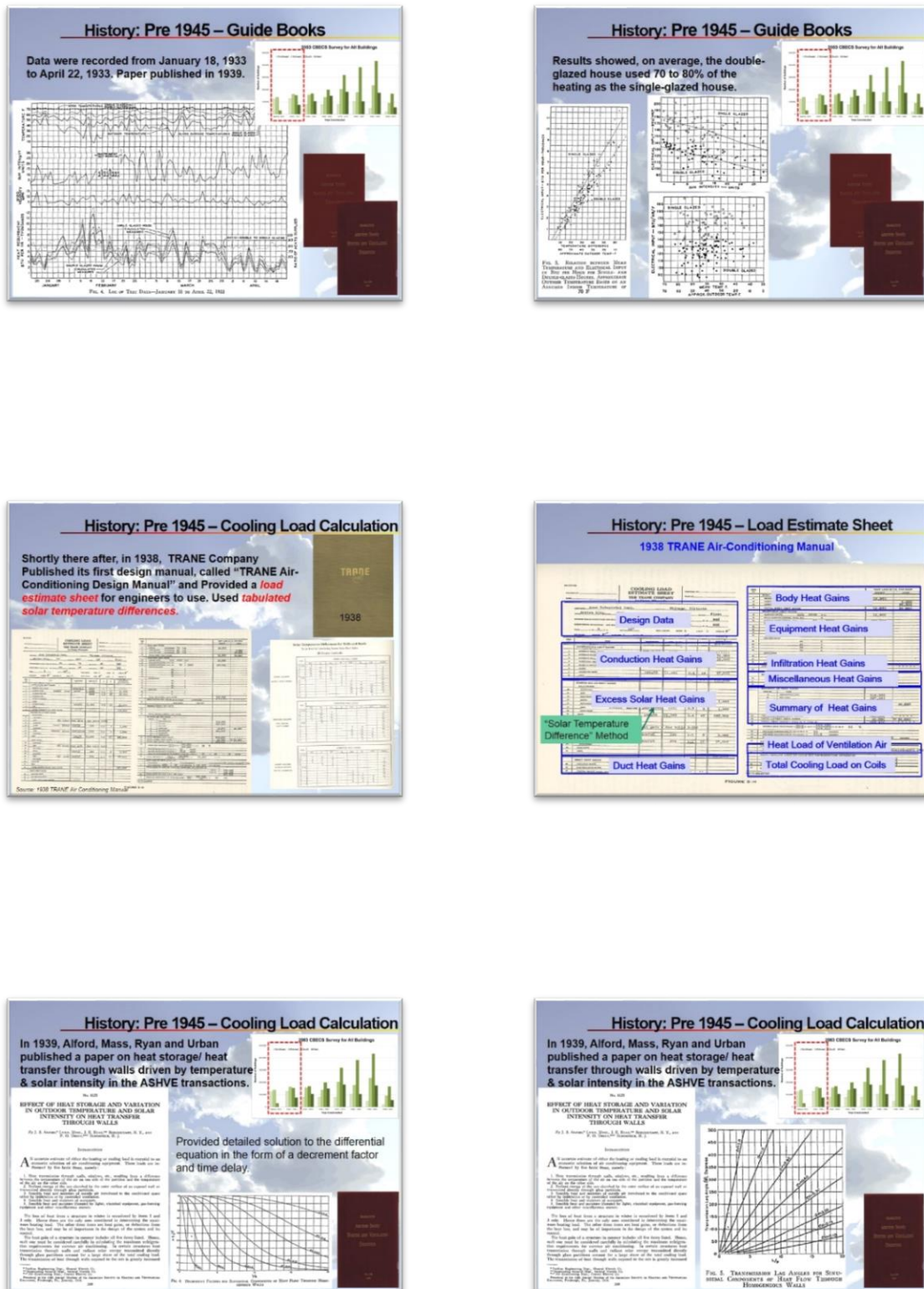


Figure 41: Presentation to IBPSA, August 2012 (continued)



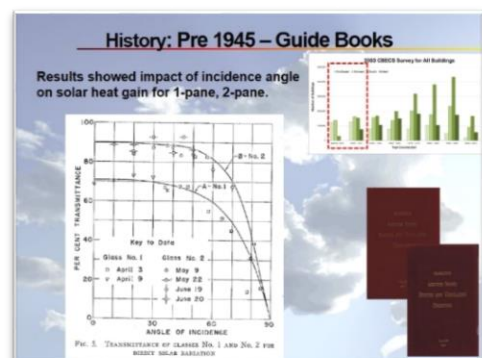
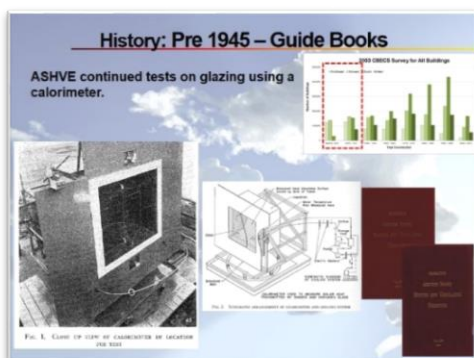
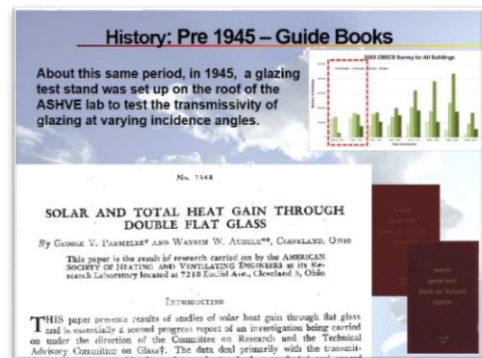
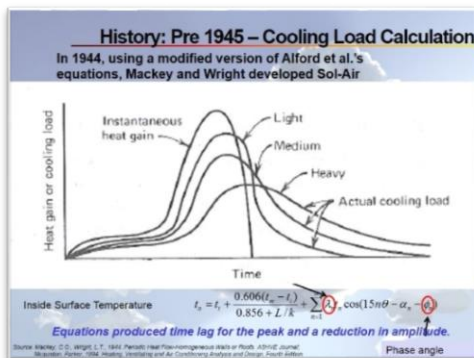
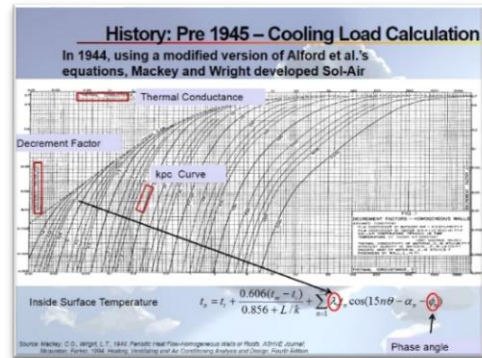
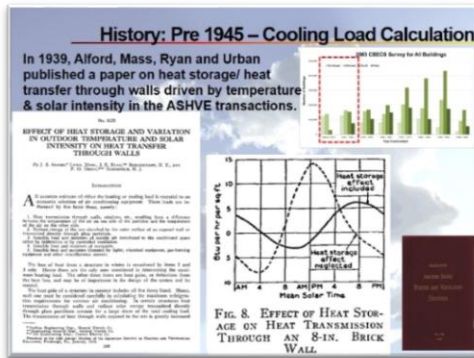


Figure 41: Presentation to IBPSA, August 2012 (continued)

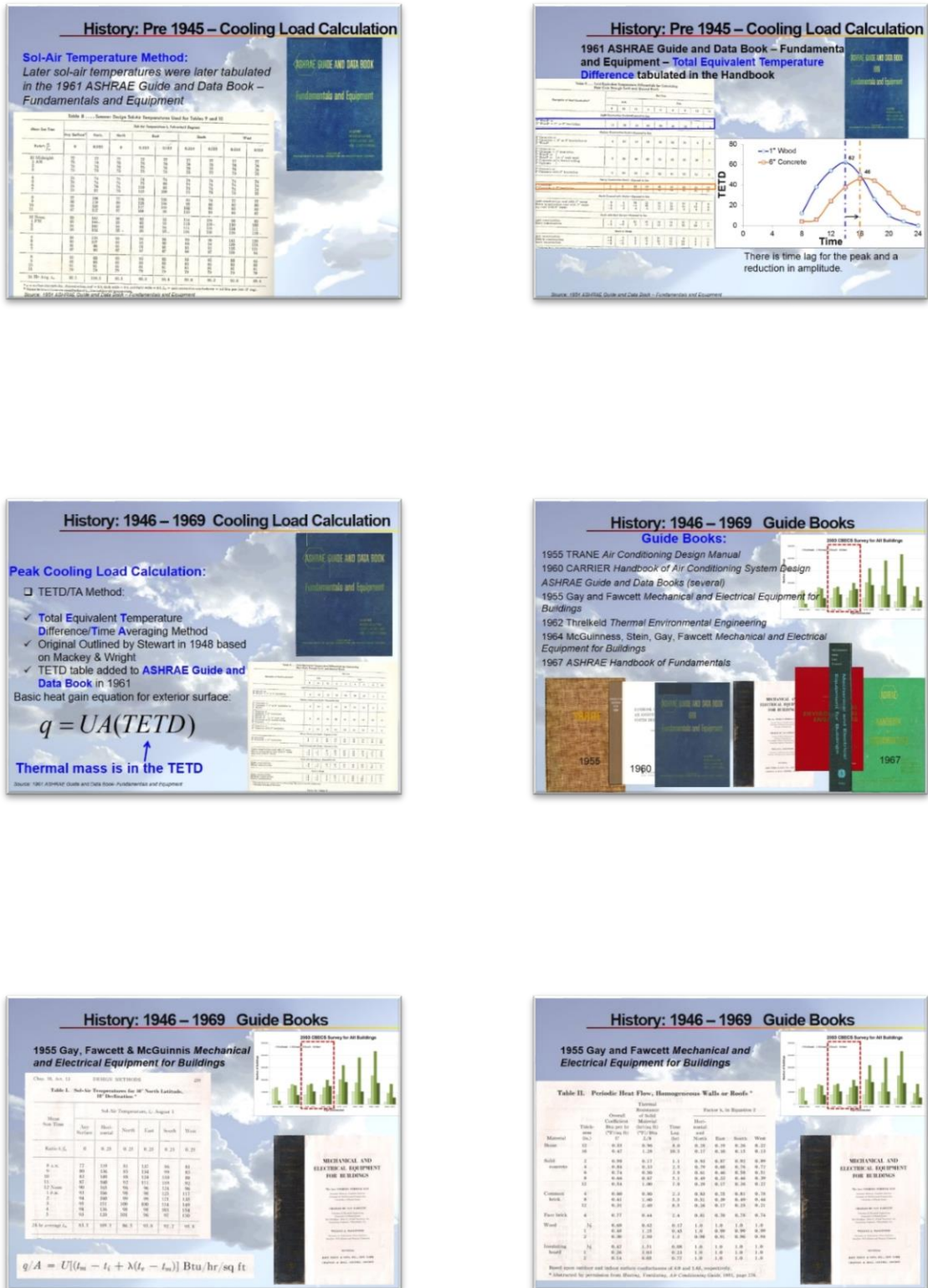


Figure 41: Presentation to IBPSA, August 2012 (continued)



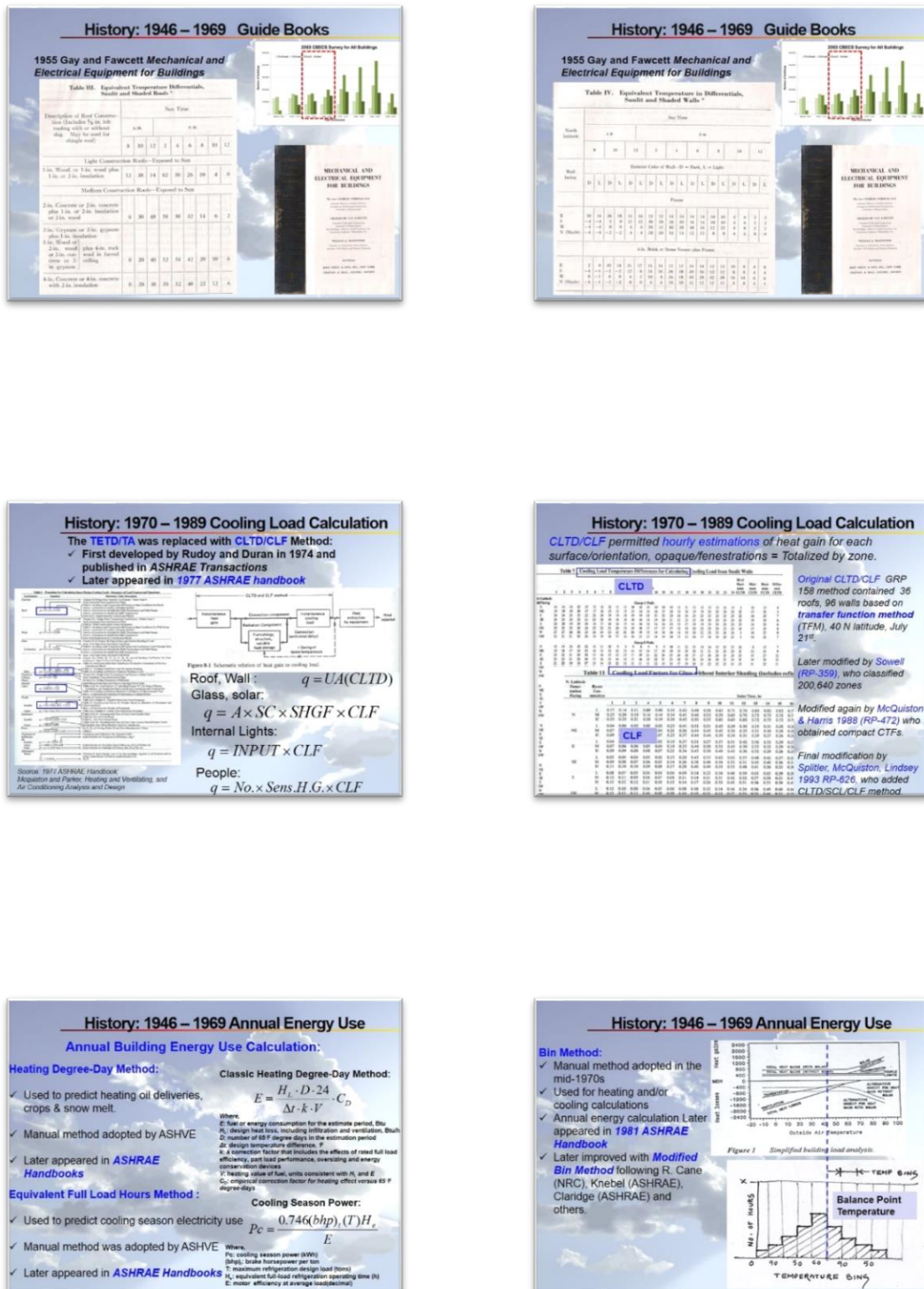


Figure 41: Presentation to IBPSA, August 2012 (continued)

### History : 1946 – 1969 Computer Developments

```

program main
  n=100000
  do while (n > 0)
    read(*,*) n
    write(*,*) 'enter number of sampling points to be used'
    read(*,*) n
    do while (n > 0)
      write(*,*) 'enter random seed'
      read(*,*) seed
      n=n-1
    end do
  end do
  n=100000
  do while (n > 0)
    write(*,*) 'DOE-2.1e'
    write(*,*) 'DOE-2.2/EQUEST'
    write(*,*) 'EnergyPlus'
    write(*,*) 'TRNSYS'
    write(*,*) 'HAP'
    write(*,*) 'Trace'
    read(*,*) choice
    if (choice == 1) then
      write(*,*) 'DOE-2.1e'
    else if (choice == 2) then
      write(*,*) 'DOE-2.2/EQUEST'
    else if (choice == 3) then
      write(*,*) 'EnergyPlus'
    else if (choice == 4) then
      write(*,*) 'TRNSYS'
    else if (choice == 5) then
      write(*,*) 'HAP'
    else if (choice == 6) then
      write(*,*) 'Trace'
    end if
    n=n-1
  end do
end

```

Today, most whole building simulation programs are still using FORTRAN

### History : 1946 – 1969 Computer Developments

- In 1957, FORTRAN I compiler was developed by John Backus and colleagues at IBM
- During 1958 – Present, FORTRAN II, III, IV, FORTRAN 66, FORTRAN 77, Fortran 90, Fortran 95, Fortran 2003, Fortran 2008 now available
- In 1960, PDP-1, the first commercial mini computer was available
- In 1964, BASIC programming was available

Today, most whole building simulation programs are still using FORTRAN

### History: 1946 – 1969 Annual Energy Use

**Thermal Network Method:**

- ✓ First appeared in 1944 at MIT, Ugrad student project
- ✓ Thermal Network models varied
- ✓ Refinement of the heat balance method
- ✓ 1958 ASHRAE research project to create thermal network model solved by analog computer.
- ✓ Later appeared in the **1997 ASHRAE Handbook**

FIG. 1—SCHEMATIC DIAGRAM OF TEST HOUSE

### History: 1946 – 1969 Annual Energy Use

**Thermal Network Method:**

FIG. 1—SCHEMATIC DIAGRAM OF TEST HOUSE

### History: 1946 – 1969 Annual Energy Use

**Thermal Network Method:**

FIG. 2—BASIC THERMAL NETWORK REPRESENTING THE IDEALIZED TEST HOUSE

### History: 1946 – 1969 Annual Energy Use

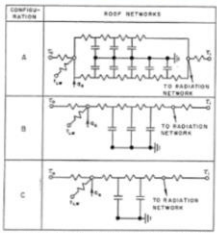
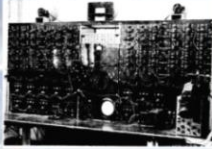
**Thermal Network Method:**

1958. Thermal mass could be represented by an electrical RC network, solved by analog computer.

Figure 41: Presentation to IBPSA, August 2012 (continued)

### History: 1946 – 1969 Annual Energy Use

#### Thermal Network Method:

1950s RC Networks:

- layered walls, roofs,
- nodal temperatures to be determined.
- solved by analog computers (i.e., equiv. electrical circuits).
- Results viewed on oscilloscope

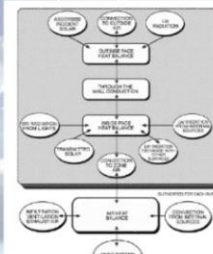
FIG. A-2—CONNECTION FROM THERMAL NETWORK CONFIGURATIONS FOR ROOF SECTION

### History: 1946 – 1969 Cooling Load Calculation

#### Computer Algorithms:

#### Heat Balance Method:

- ✓ Earliest use for general thermal modeling in aerospace and other industries
- ✓ Used in detailed analog calculation procedures by Buchberg in 1958
- ✓ Later appeared in **ASHRAE Handbooks**




Schematic of Heat Balance Processes in Zone  
(Source: 2009 ASHRAE Handbook)

### History : 1946 – 1969 Annual Energy Use

#### Computer Algorithms:

#### Thermal Response Factor Method:

- ✓ Developed by Stephenson and Mitalas in 1967, based on 1950s work by Briskin & Reque (1956), Hill (1957).
- ✓ Briskin and Reque proposed using "square waves" to represent time varying "curve" of temperature response.
- ✓ Hill's paper developed "unit triangle method to calculate time-varying 1D temperature".
- ✓ Appeared later as part of the Weighting Factor Methods in **ASHRAE Handbook**
- ✓ Used later for CLTD/CLF tables in the ASHRAE Handbook



### History: 1946 – 1969 Annual Energy Use

#### Computer Algorithms:

#### Thermal Mass: Transfer Function Method:


- ✓ ASHRAE Task Group on Energy Requirements (TGER) developed first computer-oriented method for solving dynamic H/T (5 years).
- ✓ Method introduced in the 1972 ASHRAE Handbook of Fundamentals
- ✓ Announcement of method in the Dec 1972 ASHRAE Journal

### Transfer Function Method of Calculating Cooling Loads, Heat Extraction & Space Temperature

GERALD P. MITALAS  
Member ASHRAE

A new cooling load calculation procedure, the transfer function method, has been incorporated in the 1972 ASHRAE HANDBOOK OF FUNDAMENTALS. This article presents a...




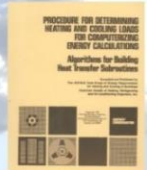
The ASHRAE Task Group on Energy Requirements after five years' work, developed a computer-oriented method that has now been incorporated in the 1972 ASHRAE HANDBOOK OF FUNDAMENTALS. This article presents a...



### History: 1970 – 1989 Guide Books

#### Guide Books:

1972 ASHRAE Handbook of Fundamentals  
1977 TRANE Air Conditioning Manual  
1975 ASHRAE Task Group on Energy Requirements: Procedure for Determining Heating and Cooling Loads for Computerizing Energy Calculations

### History: 1990 – Present Guide Books

#### Guide Books:

1993 - 2009 ASHRAE Handbook of Fundamentals  
1996 - Present TRANE Air Conditioning Manual










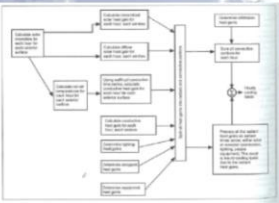



Figure 41: Presentation to IBPSA, August 2012 (continued)



### History: 1990 – Present Cooling Load Calculation

#### Radiant Time Series Method:




- ✓ First proposed by Spitler, Fisher and Pedersen in 1997 to replace RF, TETD, CLTD/CLF

### History: 1990 – Present Cooling Load Calculation

#### Radiant Time Series Method:




- ✓ First proposed by Spitler, Fisher and Pedersen in 1997 to replace RF, TETD, CLTD/CLF
- ✓ Simpler to apply than the heat balance method:
  - ✓ No exterior, interior or zone air heat balance
  - ✓ Periodic response factors vs conduction transfer functions
  - ✓ Uses predetermined zone response to account for thermal mass heat storage/release
  - ✓ Suitable for spreadsheet

### History: 1990 – Present Cooling Load Calculation

#### Residential Heat Balance (RHB) and Residential Load Factor (RLF) Methods (RP 1199):

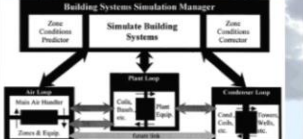


- ✓ First introduced by Barnaby, Spitler and Xiao in 2004
- ✓ Both methods used for residential calculations
- ✓ Later appeared in **2005 ASHRAE Handbook of Fundamentals**

### History: 1990 – Present Cooling Load Calculation

#### Modeling Radiant HVAC Systems Using a Heat Balance Simulation:

- ✓ First studied by Strand & Pedersen in 1994.
- ✓ First published by Strand in 2001 thesis.
- ✓ Required the development of **new type of transfer functions**.
- ✓ Now a module in the EnergyPlus program

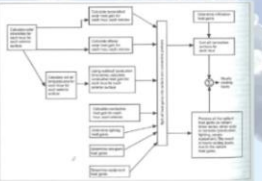
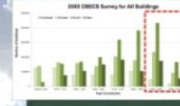





### History: 1990 – Present Text Books

#### Text Books:

2009 ASHRAE Fundamentals  
Chapter 19 – Nonresidential Cooling and Heating Load Calculations

- Covers RTS method w/example

### History: 1990 – Present Text Books

#### Text Books:

2009 ASHRAE Fundamentals  
Chapter 19 – Nonresidential Cooling and Heating Load Calculations

- Covers RTS method w/example calculation
- Contains only a description of TFM, TETD/TA, CLTD/CLF methods

#### PREVIOUS COOLING LOAD CALCULATION METHODS

Procedures described in this chapter are the most current and scientifically derived means for estimating cooling load for a defined building space, but methods in earlier editions of the ASHRAE Handbook are valid for many applications. These earlier procedures are simplifications of the heat balance principles, and their use requires experience to deal with atypical or unusual circumstances. In fact, any cooling or heating load estimate is no better than the assumptions used to define conditions and parameters such as physical makeup of the various envelope surfaces, conditions of occupancy, and so on.

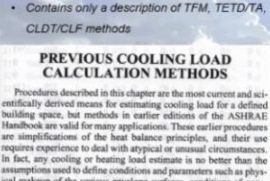






Figure 41: Presentation to IBPSA, August 2012 (continued)

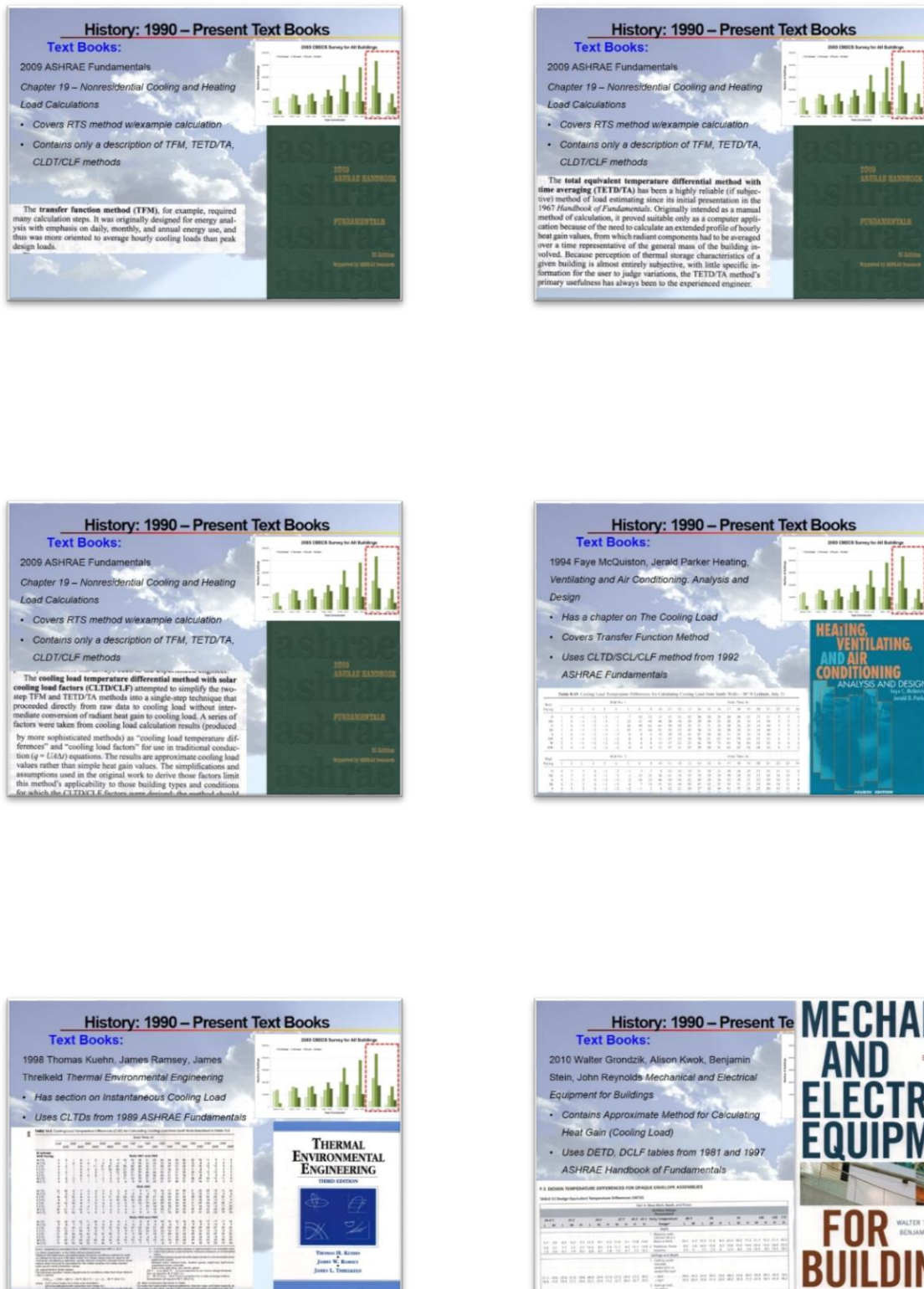


Figure 41: Presentation to IBPSA, August 2012 (continued)



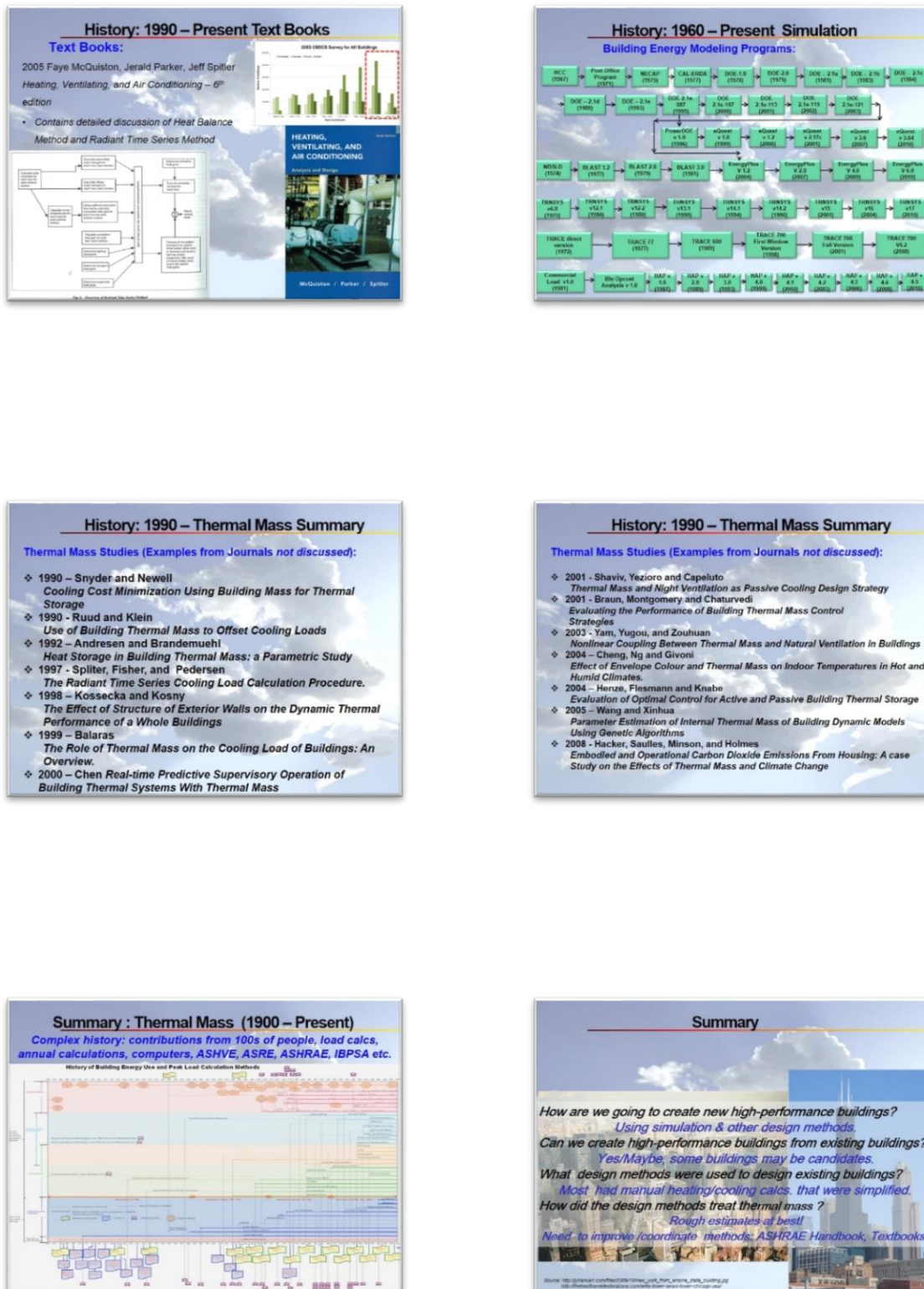


Figure 41: Presentation to IBPSA, August 2012 (continued)

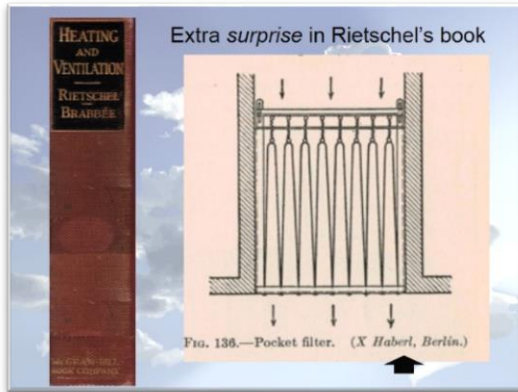


Figure 41: Presentation to IBPSA, August 2012 (continued)

Webinar to the EPA, August 2012

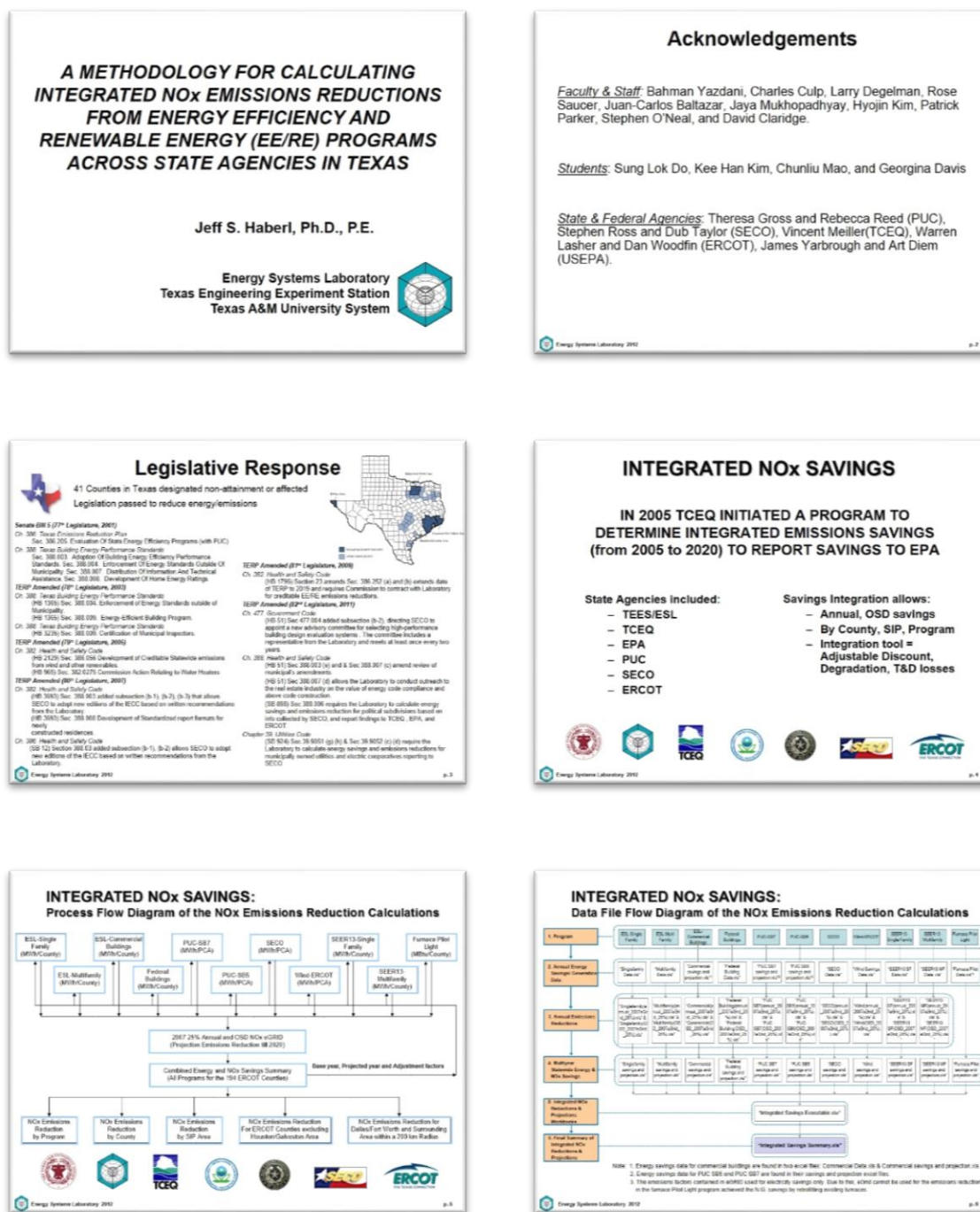


Figure 42: Webinar to the EPA, August 2012

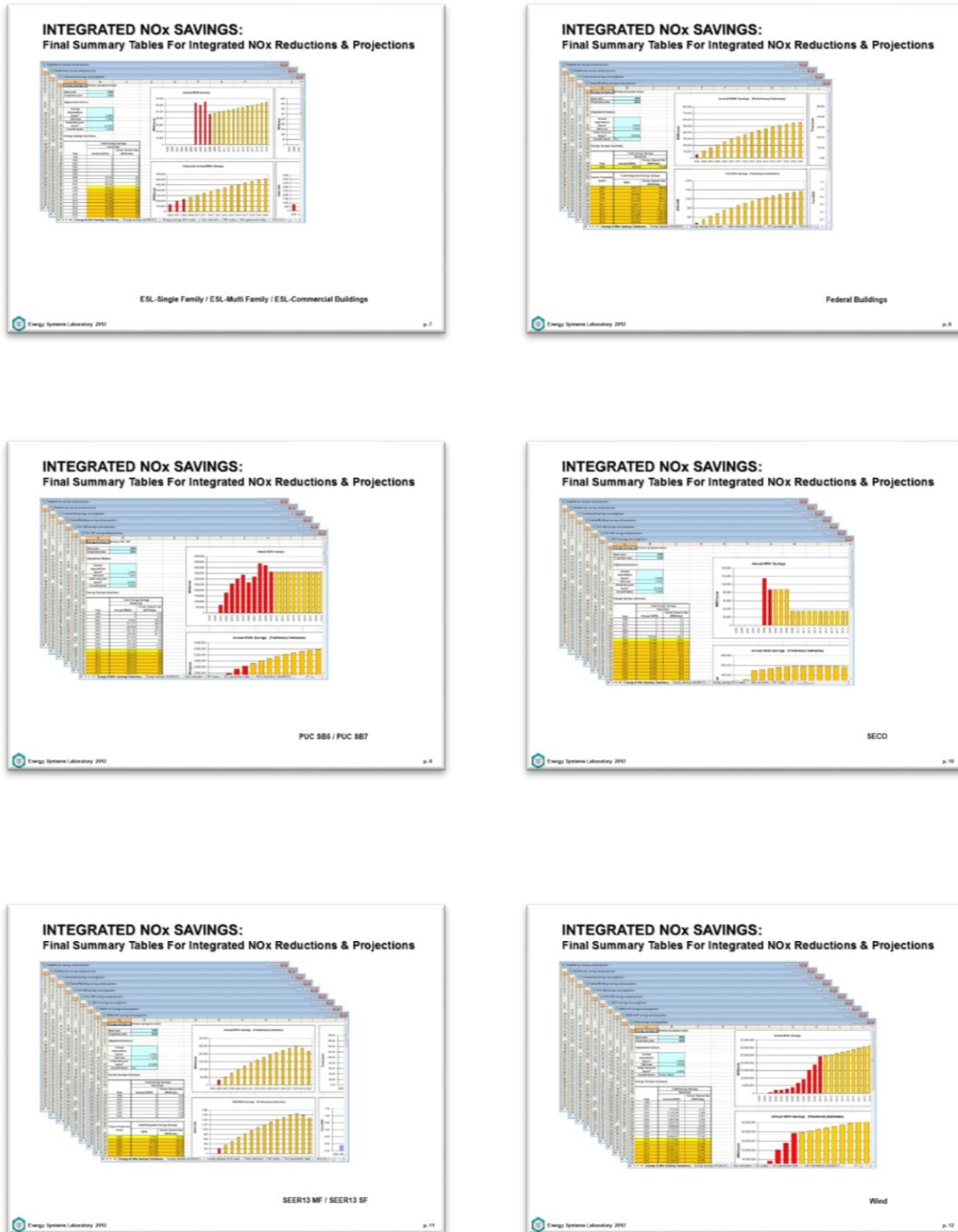


Figure 42: Webinar to the EPA, August 2012 (continued)



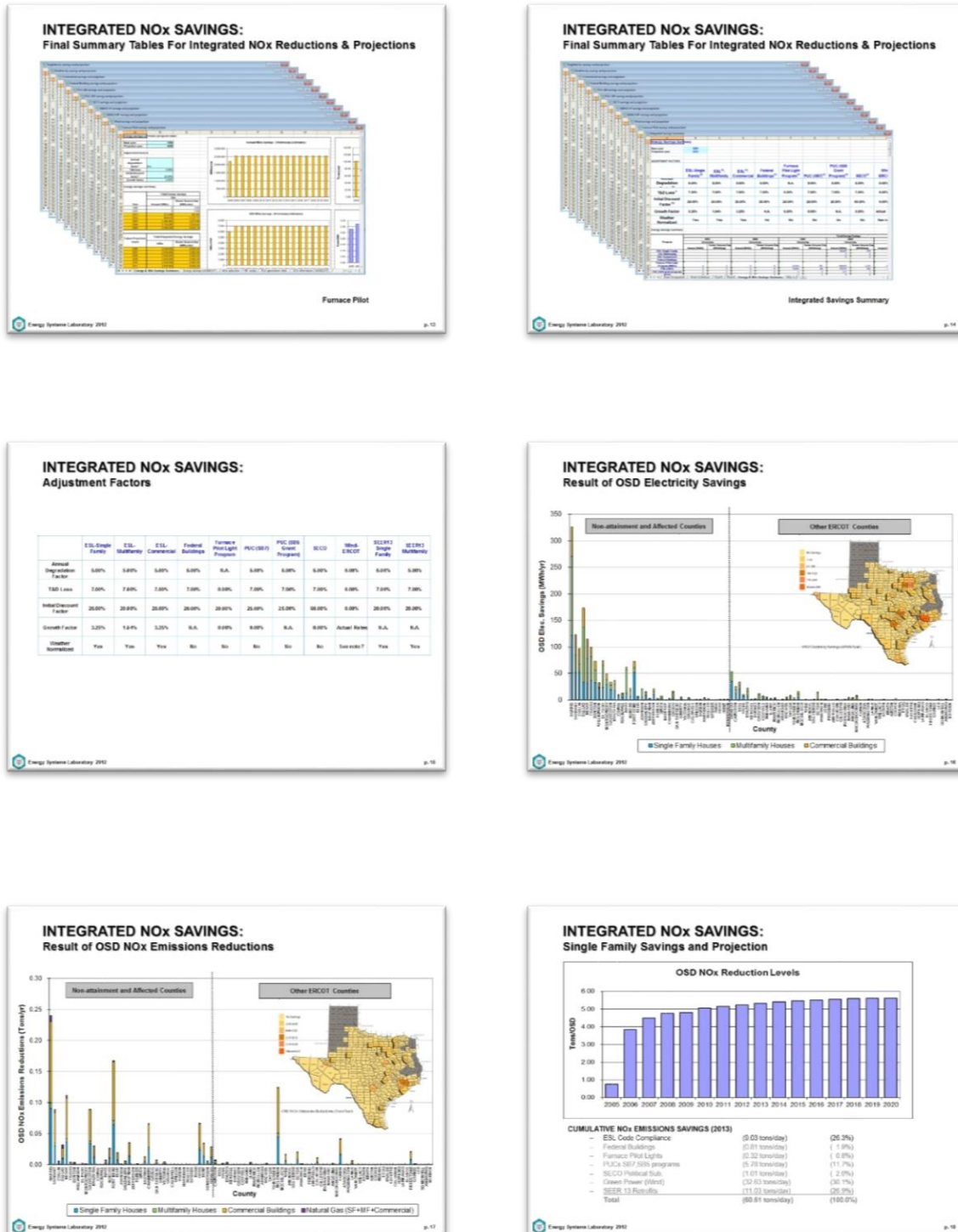


Figure 42: Webinar to the EPA, August 2012 (continued)



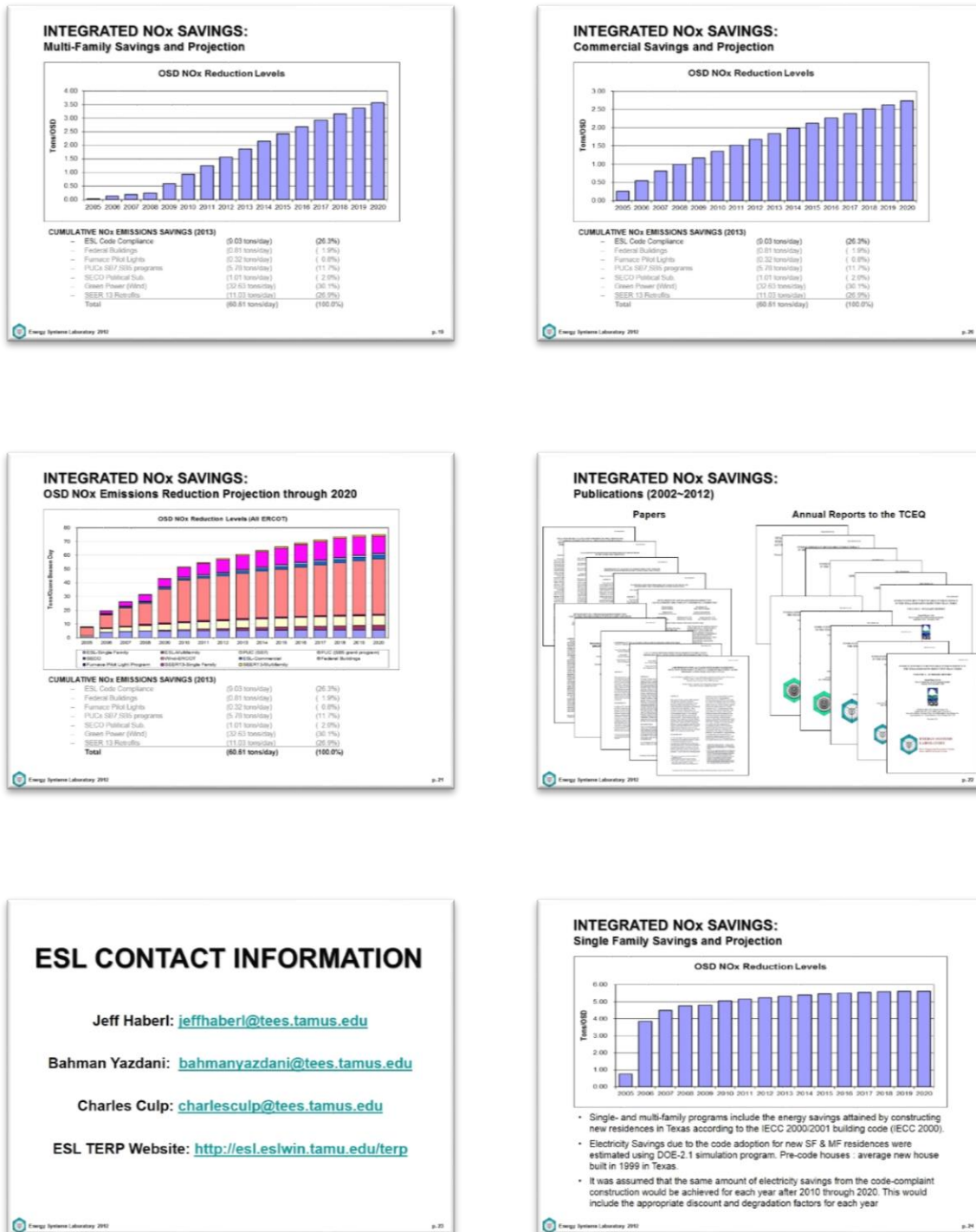


Figure 42: Webinar to the EPA, August 2012 (continued)

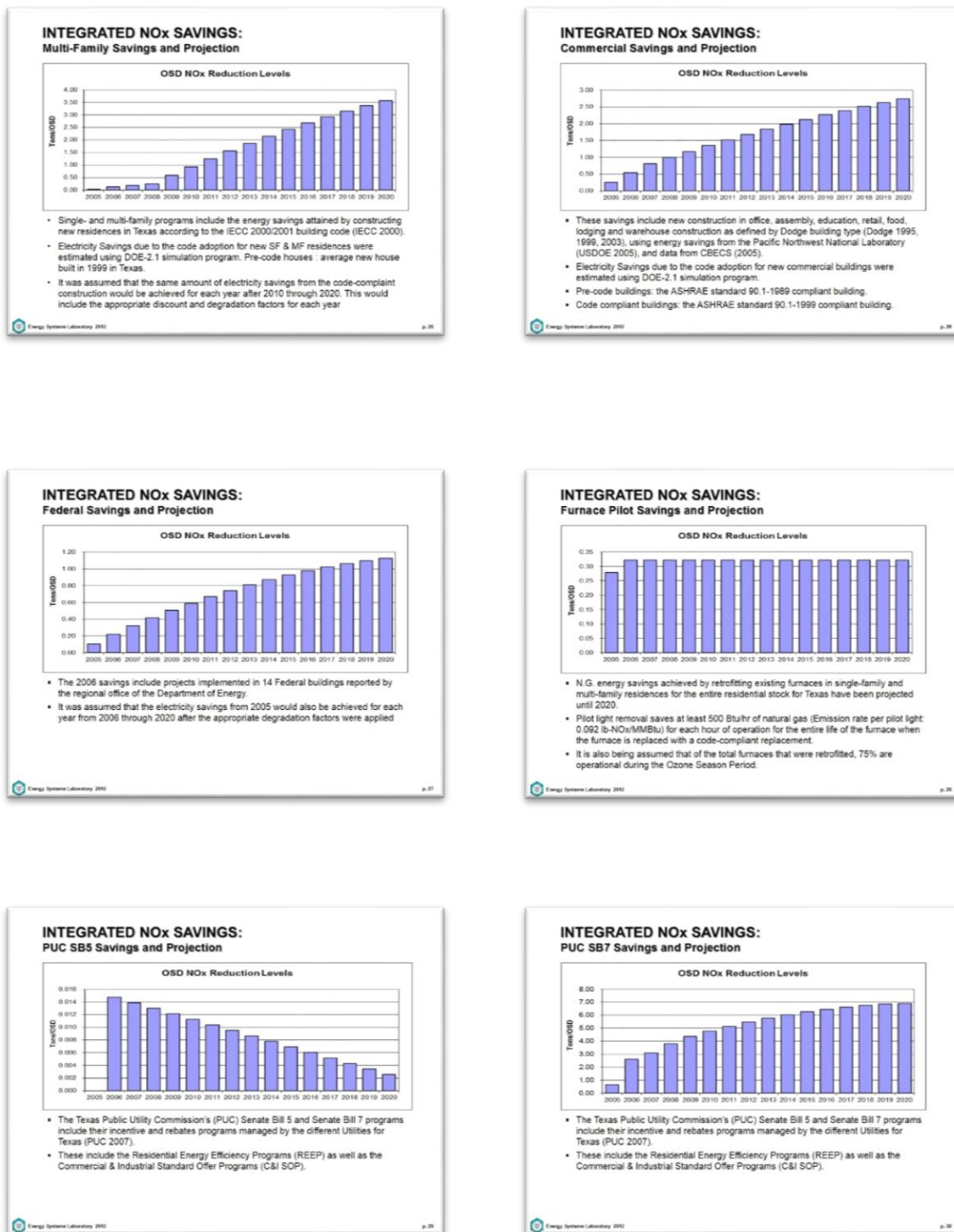


Figure 42: Webinar to the EPA, August 2012 (continued)

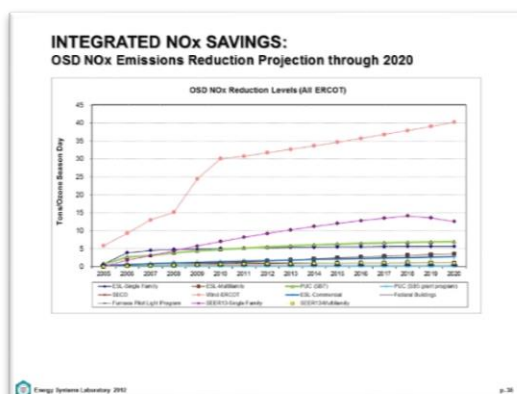
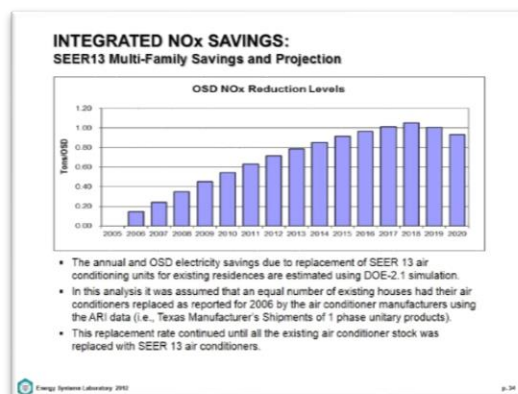
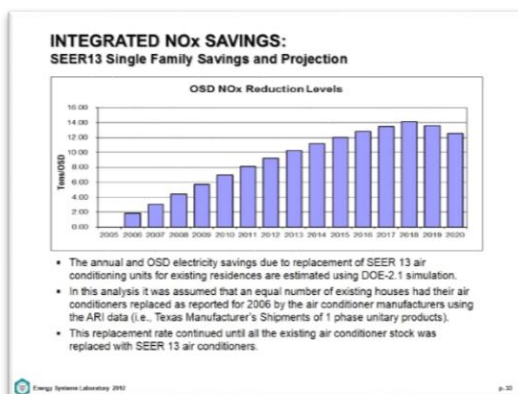
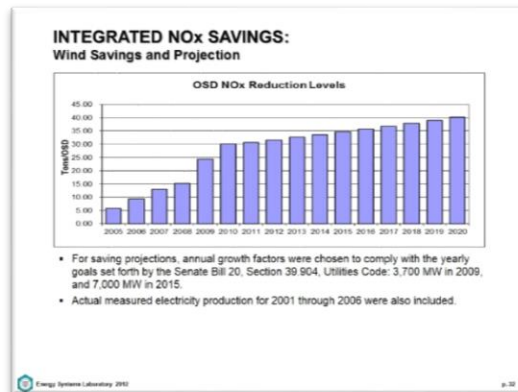


Figure 42: Webinar to the EPA, August 2012 (continued)

Presentation to the City of El Paso, September 2012



Figure 43: Presentation to the City of El Paso, September 2012

### Chapter 1 (RE) Scope and Administration

- ❑ R101.3 - Intent
  - Added “over the useful life of each building”
- ❑ R106.1 - Referenced codes and standards
  - Adds two subsections and clarifies when standards are to be considered
    - R106.1.1 Conflicts
    - R106.1.2 Provision in referenced codes and standards

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### Chapter 2 (RE) Definitions

- ❑ Revised definitions
  - Buildings - added “including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building”
  - Skylight - changed measurement from a slope of 15 degrees or more from vertical to 60 degrees or less from horizontal.

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### Chapter 2 (RE) Definitions

- ❑ New definitions
  - Building Site
  - Continuous Air Barrier
  - Demand Recirculation Water System
  - Fenestration Product, Site-Built
  - Visible Transmittance (VT)
  - Whole House Mechanical Ventilation System

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### Chapter 3 (RE) General Requirements

- ❑ Revised R303.1.3 Fenestration product rating
  - Added Visible transmittance (VT) to the NFRC 200

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### Chapter 4 (RE) Residential Energy Efficiency

- ❑ R401.2 Compliance - simplified
  - Projects shall comply with Sections identified as “mandatory” and with either sections identified as “prescriptive” or the performance approach in Section R405
- ❑ R401.3 Certificate (Mandatory)
  - Added provisions to include “the results from any required duct system and building envelope air leakage testing done on the building”

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### Chapter 4 (RE) - Table 402.1.1

CLIMATE ZONE	FENESTRATION U-FACTOR (APERTURE)	GLAZED FENESTRATION SHGC (APERTURE)	GLAZED FENESTRATION SHGC (SHADE)	ROOF U-FACTOR (HORIZONTAL)	MADE AIR (AIR/HR @ 0.01 INCHES)	FLOOR U-FACTOR (HORIZONTAL)	BASEMENT U-FACTOR (HORIZONTAL)	SLAB U-FACTOR (HORIZONTAL)	CEILING U-FACTOR (HORIZONTAL)	CHIMNEY U-FACTOR (HORIZONTAL)
1	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08
2	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08
3	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08
4	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08
5	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08
6	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08
7 and 8	0.30	0.75	0.75	0.04	15	0.08	0.08	0.08	0.08	0.08

For U-1 (Zone 1) and U-2 (Zone 2) roofs, the required U-factor of the insulation shall not be less than the U-factor specified in the table.

\* The fenestration U-factor values include air leakage. The SHGC values represent weighted averages. Fenestration U-values may be calculated from U-values of the fenestration components and air leakage. Fenestration U-values may also be calculated from U-values of the fenestration components and air leakage. Fenestration U-values may also be calculated from U-values of the fenestration components and air leakage.

Figure 43: Presentation to the City of El Paso, September 2012 (continued)



### Chapter 4 (RE) Table 402.1.3

TABLE 402.1.3  
EQUIVALENT U-FACTORS<sup>a</sup>


CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	WALL U-FACTOR	ROOF U-FACTOR	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRACK SPACE WALL U-FACTOR
1	0.30	0.35	0.055	0.082	0.047	0.064	0.300	0.477
2	0.40	0.45	0.060	0.082	0.047	0.064	0.300	0.477
3	0.50	0.55	0.065	0.082	0.047	0.064	0.300	0.477
4 through Marine	0.60	0.65	0.070	0.082	0.047	0.064	0.300	0.477
5 and Marine 6	0.70	0.75	0.075	0.082	0.047	0.064	0.300	0.477
6	0.80	0.85	0.080	0.082	0.047	0.064	0.300	0.477
7 and 8	0.90	0.95	0.085	0.082	0.047	0.064	0.300	0.477

<sup>a</sup> Transmittance U-factors shall be obtained from measurement, calculation or an approved source.  
<sup>b</sup> When more than half the insulation is on the exterior, the exterior wall U-factor shall be a maximum of 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.082 in Climate Zone 5 and Marine 6, and 0.057 in Climate Zones 6 through 8.  
<sup>c</sup> Basement wall U-factor of 0.300 is non-vented basements as defined by Figure R501.1 and Table R501.1.

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### Chapter 4 (RE)


- R402.2.3 Eave baffle
  - For air permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.



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### Chapter 4 (RE) Table 4.2.2.6

- R402.2.6 Steel-frame ceilings, walls, and floors



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### Chapter 4 (RE)

- 402.2.12 Sunroom insulation
  - All sunrooms must meet the insulation requirements of this chapter
  - Exceptions - with thermal isolation
    - Minimum ceiling insulation R-values
      - Climate Zones 1 - 4 --- R-19
      - Climate Zones 5 - 8 --- R-24
    - Minimum Wall R-value
      - Climate Zones 1 - 8 --- R-13
    - Walls separating the sunroom from the conditioned space shall meet the building thermal envelope requirements

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### Chapter 4 (RE)

- 402.2.3.5 Sunroom U-factor
  - All sunrooms must meet the fenestration requirements of this chapter
  - Exception - sunrooms with thermal isolation
    - Climate Zones 1 - 4 --- maximum U-factor 0.45; and
    - Maximum skylight --- U-factor 0.70
    - New fenestration separating the sunroom from the conditioned space shall meet the building thermal envelope requirements

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### Chapter 4 (RE)

- R402.4 Air leakage (Mandatory)
  - The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements to Section R402.4.1 through R402.4.4
  - R402.4.1 The building thermal envelope shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar material shall allow for differential expansion and contraction

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Figure 43: Presentation to the City of El Paso, September 2012 (continued)





Figure 43: Presentation to the City of El Paso, September 2012 (continued)

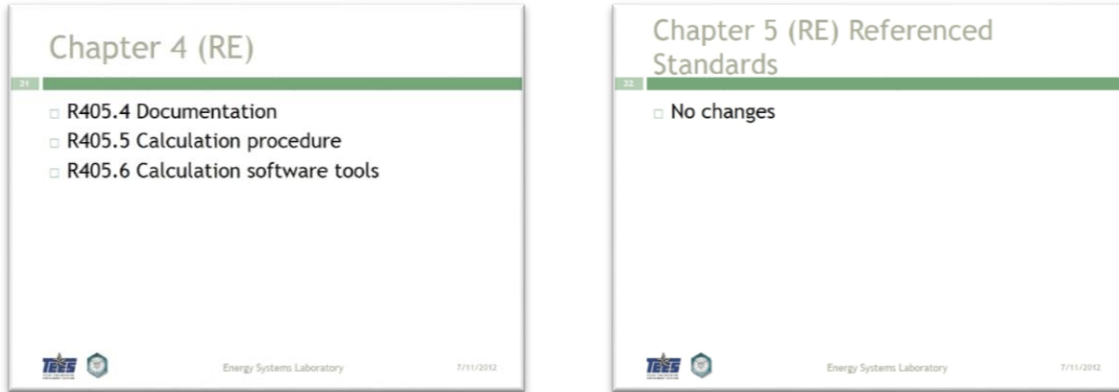


Figure 43: Presentation to the City of El Paso, September 2012 (continued)

Presentation to SPEER, September 2012

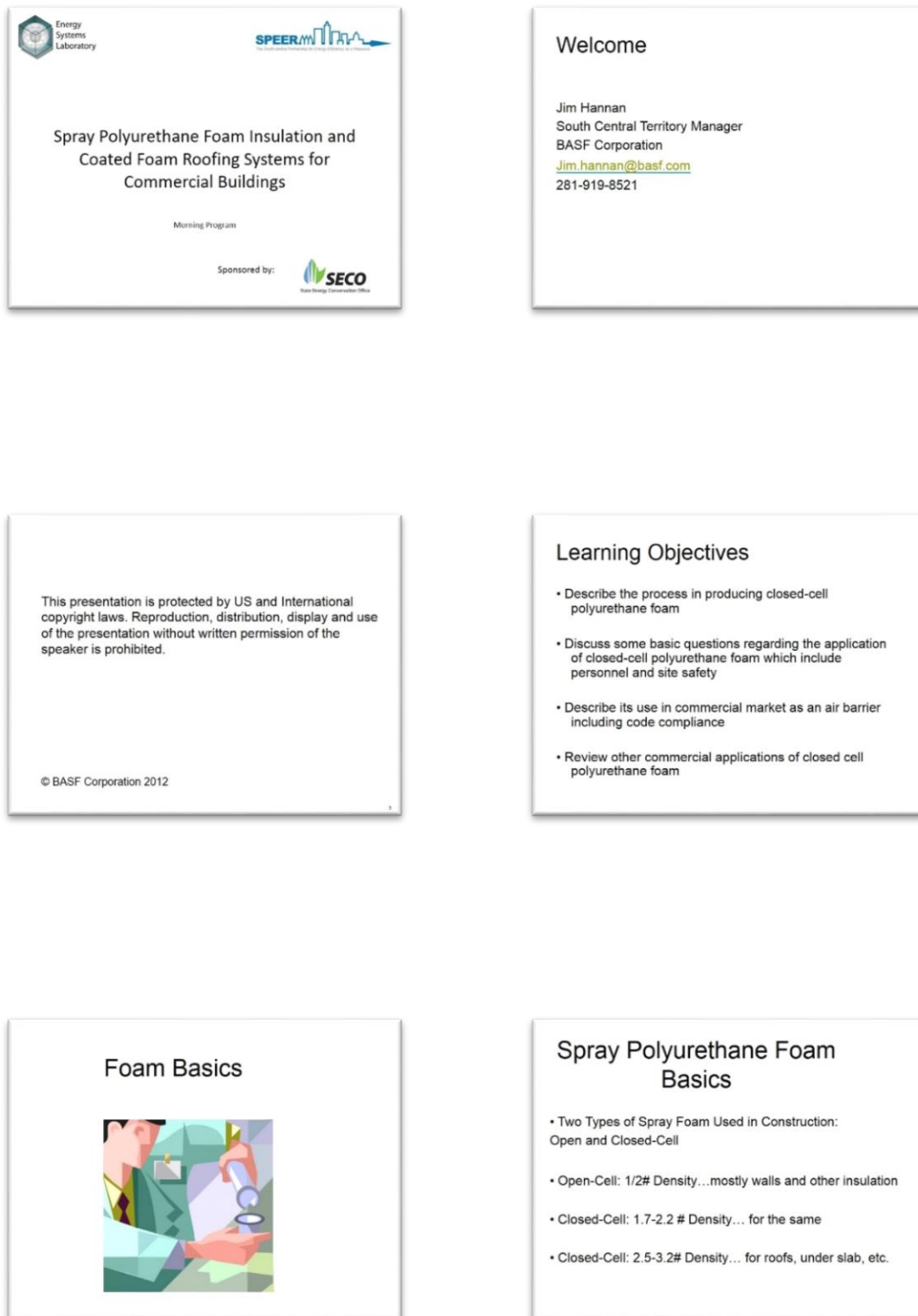
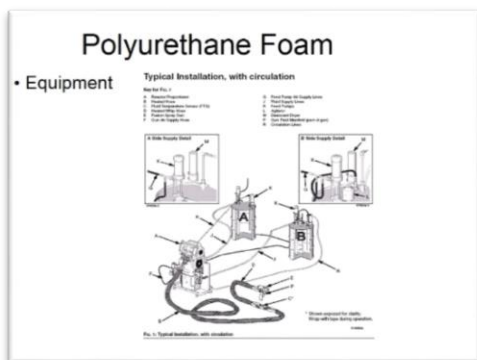


Figure 44: Presentation to SPEER, September 2012 (continued)





## Polyurethane Foam Basics (closed-cell)

- Created by combining two liquids: an "A" and a "B"
  - A - Isocyanate or "hardener"
  - B - Polyol- usually the medium for fire retardants, smoke suppressants and the Blowing Agent
- Both liquids are heated and pumped in 1:1 proportion
  - Both liquids stay apart until they meet at the tip of the spray nozzle
  - Foam is dispensed at approx 120 degrees F

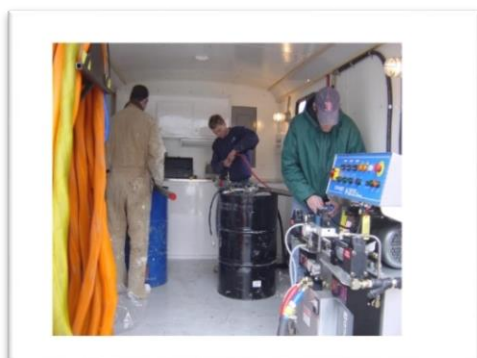
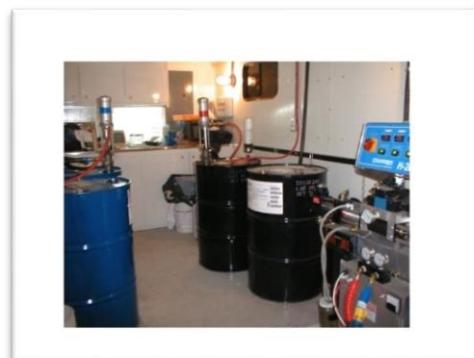
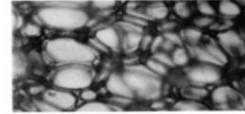


Figure 44: Presentation to SPEER, September 2012 (continued)

### Closed-Cell Basics

- "Exothermic" chemical reaction - when the two components meet
  - Heat and pressure create more heat
- It's the Blowing Agent (BA)...
  - It is the BA that makes the physical properties
  - BA is twice as efficient as a thermal insulator as air
  - Low density foams - don't use a gas blowing agent
- Microscopic cell structure created in this fashion is filled with an insulating gas
  - Over One Million closed cells per cubic inch



100X Magnification of closed-cell foam

### Closed-Cell Basics

- Liquids reach "cream and tack-free time" between 3 and 9 seconds.
- Foam actually expands away from the substrate creating foam, insulation, and vapor resistance: all in a single application.
- "Creep"
  - When foam grows laterally into gaps, crevices and other imperfections conventional insulation cannot get.

### Closed-Cell Basics

- Cure Time
  - Time at which 90% of the physical properties of foam are realized
- At 72F, 90% of physical properties are evident within one hour
  - Additional 10% within 24 to 72 hours
- As exothermic reaction (heat) dissipates, curing slows
  - Cooler substrates and ambient temperatures slow cure time



### Temperatures

- 20 F to 60 F **Cold or Winter**
- 50 F to 80 F **Normal or Fast**
- 60-90 F+ **Slow or Hot**
- The foam reaction can be controlled with the formulation to provide for the optimum foam performance at different temperature ranges
- Keeping temperatures of the drums at 70 F helps minimize equipment processing problems!

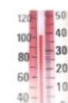


Figure 44: Presentation to SPEER, September 2012 (continued)

### Target Materials

- Heat Sink: Those materials which are very dense that will absorb heat or energy
- Non Heat Sink: Those materials which are lightweight and less dense.



### Closed Cell Basics Typical Questions.....

- Why the moon suit ?
- What will foam stick to?
- What is the acceptable substrate temp?
- What precautions should be taken on site while spraying?
- What is the pass thickness? If the foam creates an exothermic reaction, then what should the temp of the foam be before a second pass?
- How do you know if a substrate is too wet to spray?

### Basics

- If all else fails, send someone over to ask.....



Only Kidding!

### Air Barriers



### Air Barrier System Considerations

- Air barriers are not just materials
- They are an assembly of materials designed and installed to create a plane of air tightness
- You must be able to "connect the dots"
- Air barriers not only control air from moving in and out of buildings but in between conditioned spaces
- Insulation needs to be considered
- Building science considerations
- Location, climate, and building use

Figure 44: Presentation to SPEER, September 2012 (continued)

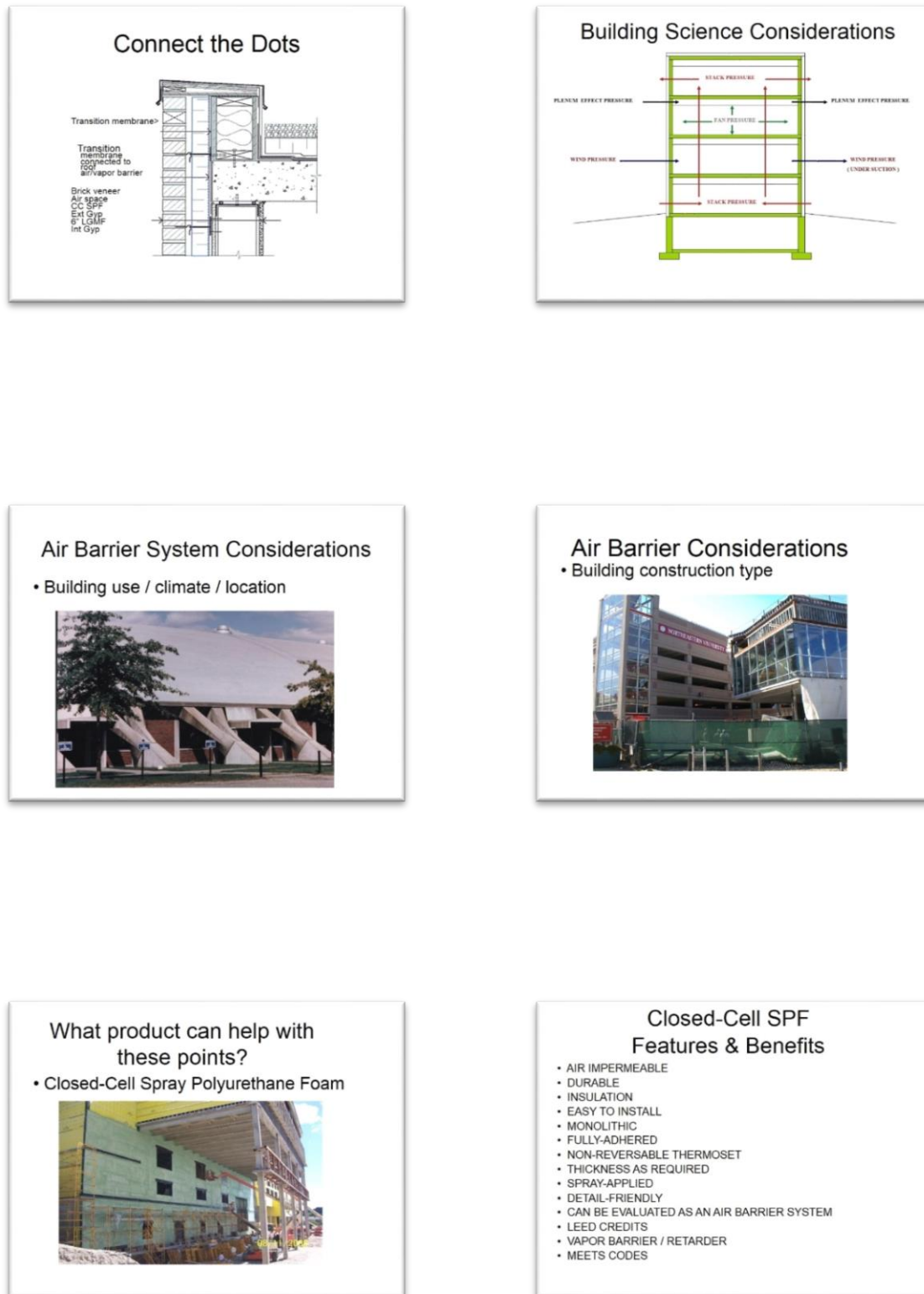


Figure 44: Presentation to SPEER, September 2012 (continued)



Figure 44: Presentation to SPEER, September 2012 (continued)



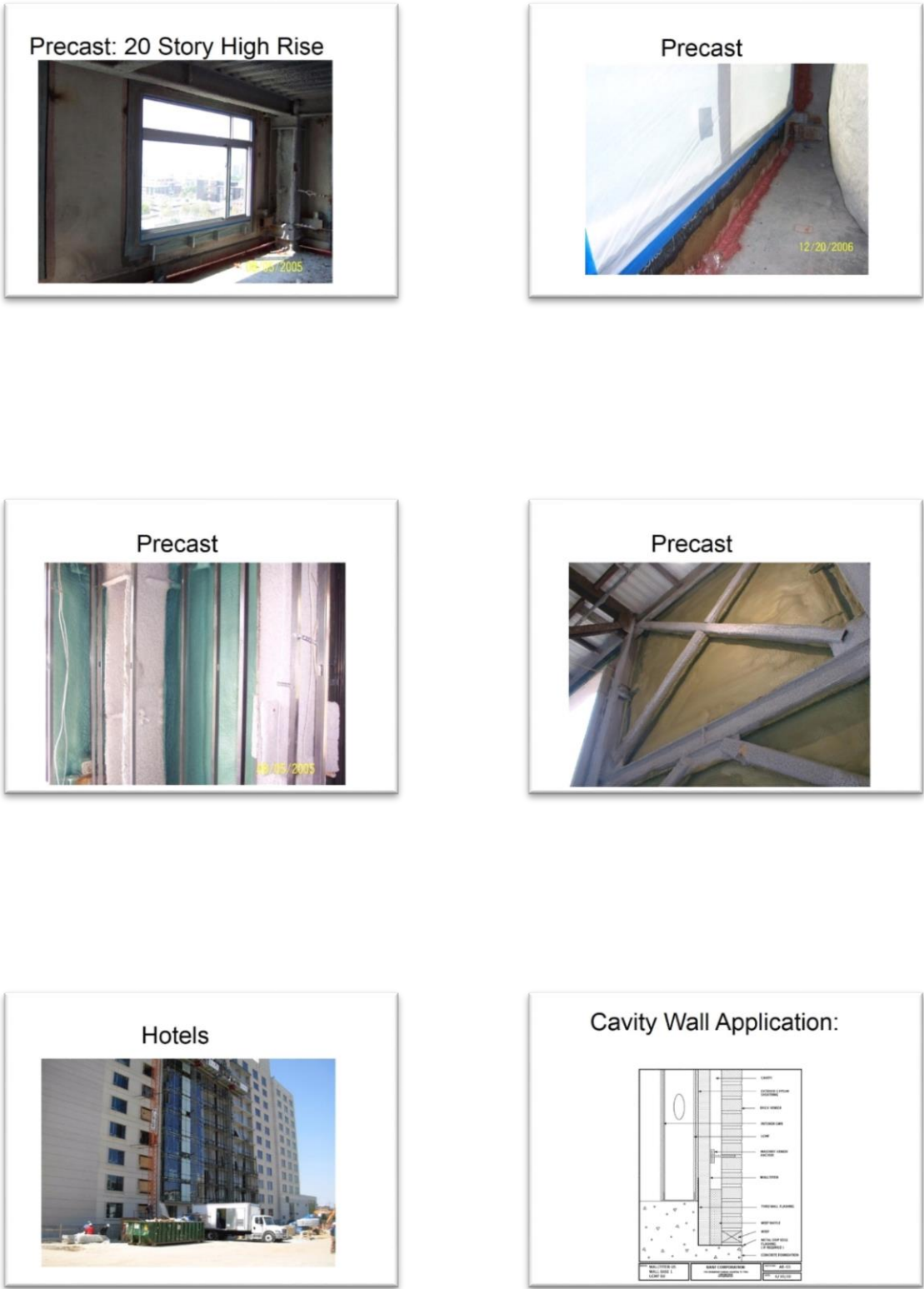


Figure 44: Presentation to SPEER, September 2012 (continued)

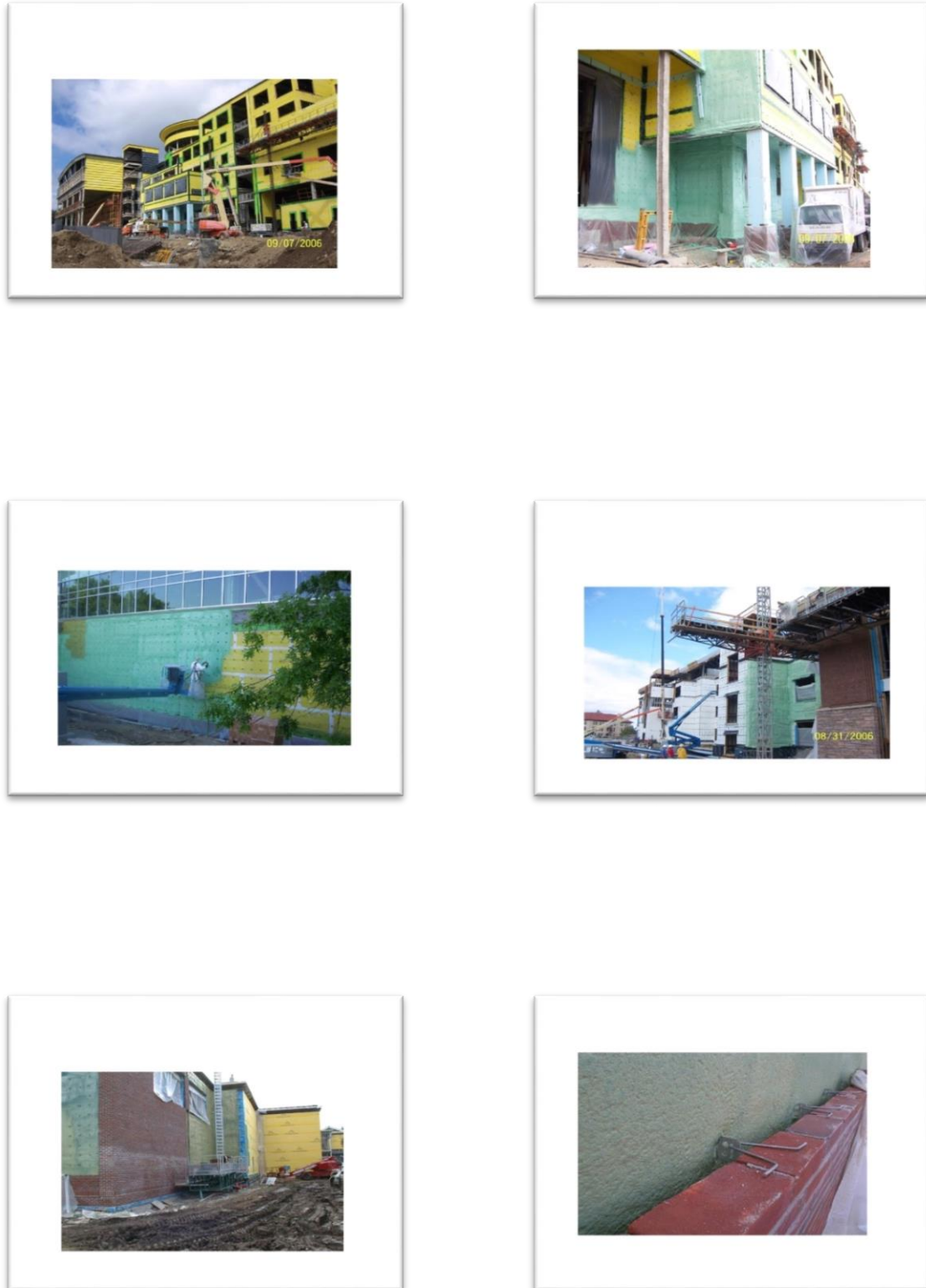


Figure 44: Presentation to SPEER, September 2012 (continued)



Figure 44: Presentation to SPEER, September 2012 (continued)

Before



After



High Performance



Single & Multi-Wythe Walls



Other uses for closed-cell  
spray polyurethane foam in  
construction....



Figure 44: Presentation to SPEER, September 2012 (continued)

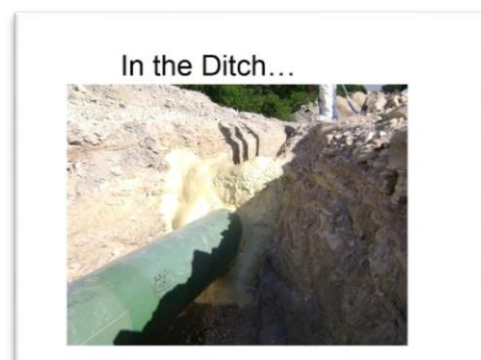
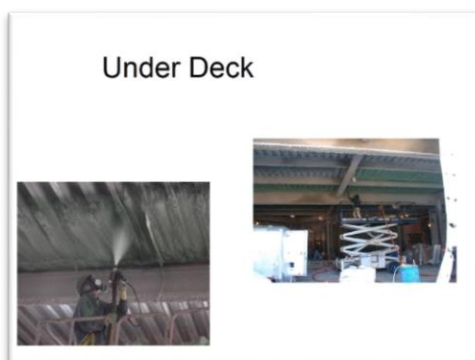
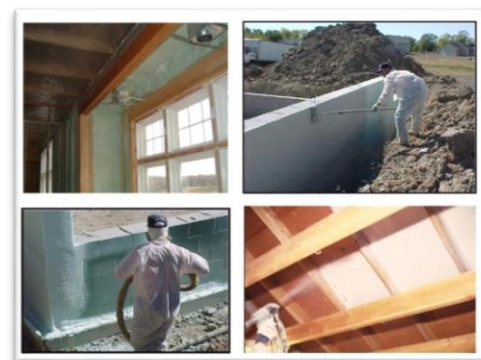
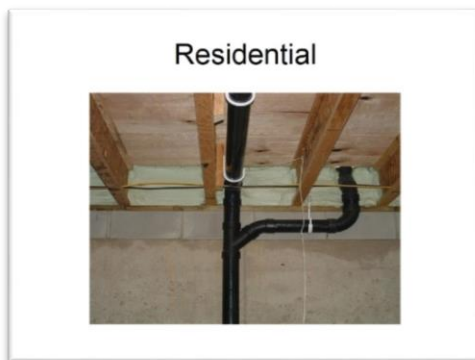
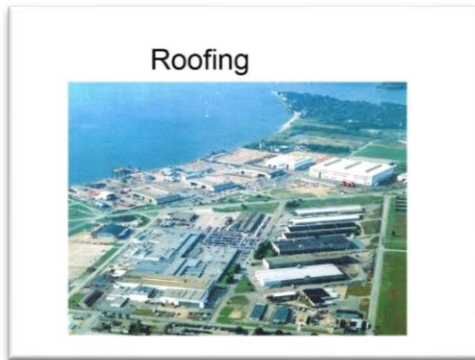


Figure 44: Presentation to SPEER, September 2012 (continued)



Digesters



Digesters



Wine Tanks



Champagne



"We will sell no wine before  
its time..."



Questions???



Figure 44: Presentation to SPEER, September 2012 (continued)

## Coated Foam Roofing Systems

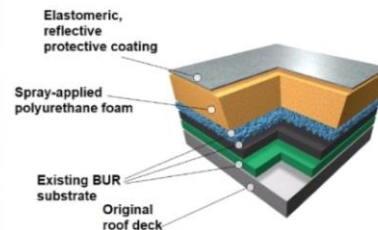
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### Learning Objectives

- Describe the application developments of coated foam roofing systems
- Explain the construction detailing benefits of a spray polyurethane roofing installation
- Describe the performance attributes exhibited in coated foam roofs
- Identify the environmental and building sustainable contributions of coated foam roofing systems

### Coated Foam Roofing System



### Industry History

- 1930s WWII and product development
- 1940s Process improvements
- 1960s Gusmer field processing equipment  
SPF roof and wall insulation applications
- 1970s Silicone coatings developed  
Energy and Insulation influence  
Naval study and acceptance - UL 1256  
Dow Corning warranty program standard
- 1980s Naval standards spread
- 1990s Robotic Technology

### Industry History

- 1990 SPFD Accreditation program
- 1991 CFC's phase out to HCFC's
- 1996 NRF Study Phase 1
- 1997 NRCA SPF Roof Manual
- 1998 Report Issued, Positive Results
- 2003 NRF Study Phase 2
- 2004 HCFC 141b phase out to HFC 0 ozone depleting blowing agents
- 2005 Wide spread acceptance as a superior insulation and energy saving system

Figure 44: Presentation to SPEER, September 2012 (continued)

### Industry Study - Existing SPF Roof Systems - Phase 1 1998

- Study by National Roofing Foundation (NRF) of existing spray polyurethane foam roof systems
- Lead by Rene Dupuis, Ph.D., PE, Structural Research, WI, a renown roofing expert.
- A 2 year comprehensive study
- Investigated 140 roofs in 5 different regions across U.S.

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### Industry Study - Existing SPF Roof Systems - Phase 1 1998

- The study investigated the following roof profiles:
  - SPF roofs in Various Climates
  - SPF & Acrylic Coatings
  - SPF & Urethane Coatings
  - SPF & Silicone Coatings
  - SPF & Aggregate covering Systems

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### Industry Study - Existing SPF Roof Systems - Phase 1 1998

- The study documented the following performance:
  - Average roof maximum performance = 14.2 years
  - Average roof size = 40,541 sq. ft.
  - 97 percent customer satisfaction
  - Conclusion: SPF roofs are performing very well

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### Industry Study - Field Performance of Roof Flashings - Phase 2 2003

- Study by National Roofing Foundation (NRF) of existing spray polyurethane foam roof systems
- Lead by Rene Dupuis, Ph.D., PE, Structural Research, WI, a renown roofing expert.
- Investigated 188 roofs across U.S.
- Roof age - Up to 31 years old
- 40 projects in the study were recoated at an average age of 15 years
- Self flashing of SPF roofing systems was determined to be satisfactory and could eliminate the cost of counter flashings and control joints

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### Industry Study - Field Performance of Roof Flashings - Phase 2 2003

- The study documented the following performance:
  - SPF details are by nature very simple
  - SPF details often do not use counter flashings
  - Conclusion: SPF and appropriate coatings were observed to work quite well as singular flashing systems

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### Industry Study - Field Performance of Roof Flashings - Phase 2 2003

- SPF details are by nature very simple



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Figure 44: Presentation to SPEER, September 2012 (continued)

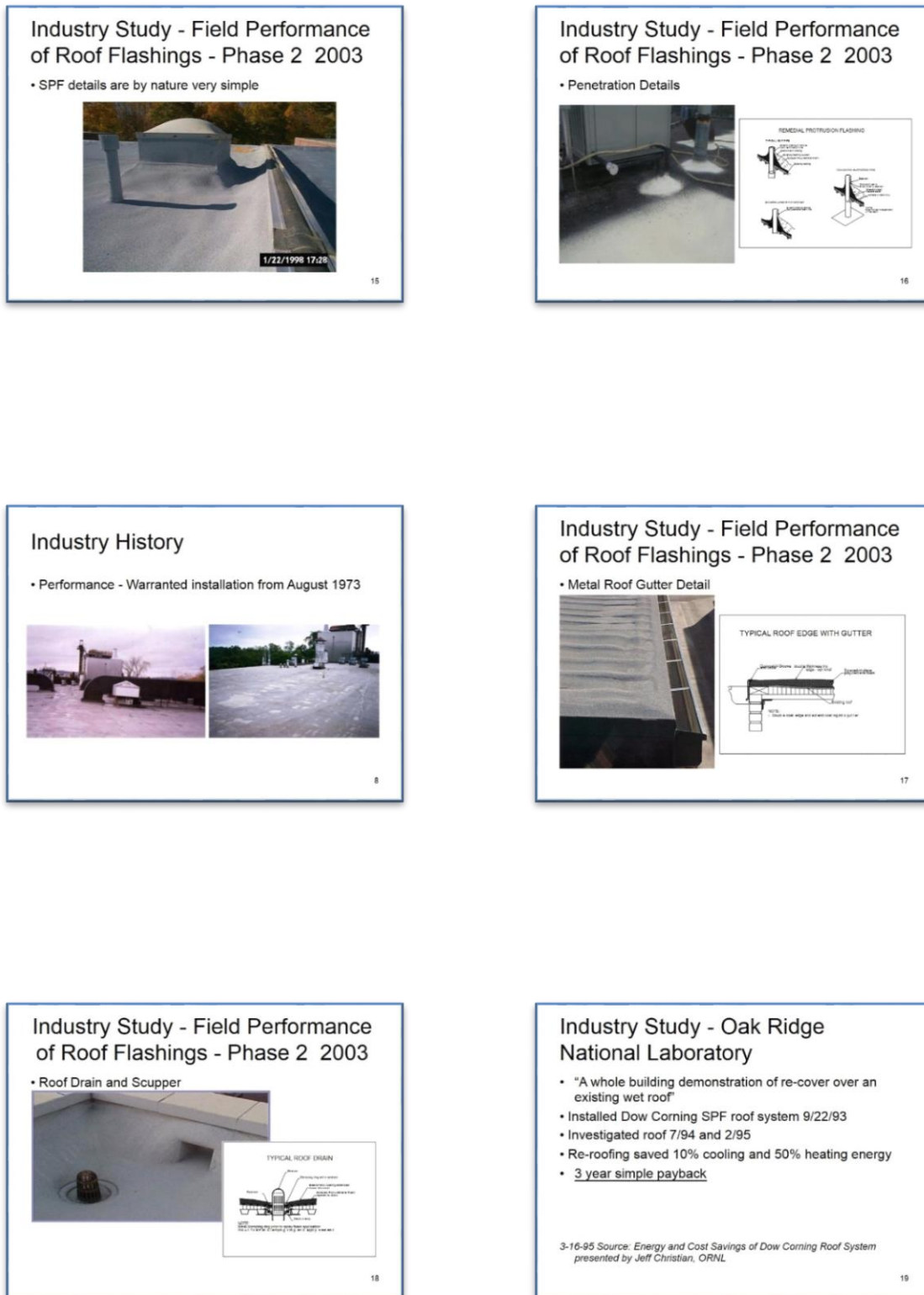


Figure 44: Presentation to SPEER, September 2012 (continued)

## Industry Program - Performance Based Studies Research Group

### • The **ALPHA** Program

- The Program is the result of studies conducted by the Performance Based Studies Research Group (PBSRG) at Arizona State University
- **ALPHA** has defined quantifiable, verifiable standards for excellence in roof performance
- The Performance Information Procurement System (PIPS) is unique in its ability to go beyond basic cost and specification criteria to identify the true value of contractors and systems based on measurable, quality-related factors

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## Industry Program - Performance Based Studies Research Group

### • The **ALPHA** Program

- An **ALPHA** roof provides high performance by combining the efforts of the leading coating manufacturer, the highest quality SPF and highly qualified contractors
- The **ALPHA** Program is voluntary and open to all manufacturers & contractors who meet the same high level of scrutiny and performance

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## SPF Product Basics

- Chemistry of SPF roofing systems
  - No volatile organic compounds (VOCs)
  - **Zero-ozone-depleting blowing agents**
    - No CFCs or HCFCs
  - ENERGY STAR® listed insulation material
  - ENERGY STAR® listed coatings

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## SPF Product Basics

### • **245fa Water Blowing Agents - 01-01-2005**

#### • Standard SPF Roofing System

- Closed Cell Content >90%
- Compressive Strength 50 psi
- Thermal Resistance initial 0.15 (6.7)
- Thermal Resistance aged 0.17 (6.3)
- Dimensional Stability - 28 days +2.5%
- Water Absorption 0.36 %
- Water Vapor Transmission 0.8 perms
- Passes UL 790

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## Recycled and Renewable Content

- Post-consumer scrap plastics reprocessed into B-component ingredients
- Renewable or plant-grown materials (sugar beets, cane products) processed into B-component ingredients



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## SPF Product Basics

- Application with standard equipment
- Smooth surface texture
- Seamless insulating air barrier



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Figure 44: Presentation to SPEER, September 2012 (continued)



## Elastomeric Coating Basics

- Chemistry of elastomeric coatings
  - Acrylic - Little to no VOCs
    - Least expensive
    - Requires more coats to achieve required millage
    - Requires temperatures above 50 F for curing
    - Requires good drainage
    - Available in white and most colors
      - 50-60% solids
  - Silicone - Low VOC coating
    - Moderate price
    - UV stable and chemical resistant
    - Best weathering resistance with renewal after 15+ years
    - Not for heavy traffic on roof
    - Available in white, beige or gray colors
      - 80-97% solids

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## Elastomeric Coating Basics

- Chemistry of elastomeric coatings
  - Polyurethane - Low VOC coating
    - Moderate to High priced
    - Can use an aliphatic topcoat for UV stability
    - Uses organic solvents which are VOCs
    - Toughness against hail and roof traffic
    - Good chemical resistance
    - 70-80% solids
  - Polyurea - No VOCs
    - 100% solids
    - Very fast cure
    - Most durable coating
    - Requires specialized equipment and applicator

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## Elastomeric Coating Basics

- Alternative Membrane Coverings
  - EPDM (ethylene-propylene-diene-monomer)
  - TPO (thermoplastic-polyolefin)
  - PVC (polyvinyl-chloride)

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## Performance - Key Features

- Seamless protection from roof edge to edge



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## Performance - Key Features

- Self-Adhered



30

## Performance - Key Features

- SPF is self-flashing - creating quick and effective waterproofing seals

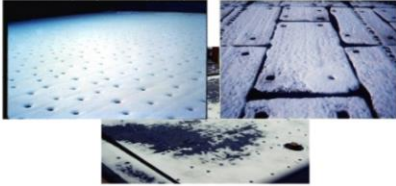


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Figure 44: Presentation to SPEER, September 2012 (continued)

### Performance - Key Features

- Spray Polyurethane Foam Roofing Systems have no thermal bridging at joints or fasteners



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### Performance - Key Features

- Energy Efficient
  - Energy savings up to 50% dependent upon existing conditions
  - Smaller, less costly heating and air conditioning systems required
  - Reduced maintenance on heating and cooling systems
  - Helps maintain required interior temperature conditions

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### Performance - Application

- SPF is processed through specialized heated, high-pressure, proportioning equipment



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### Performance - Application

- Pre-engineered metal roofs are excellent candidates for SPF



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### Performance - Application

- Metal Roof Retrofit



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### Performance - Application

- Built-Up Roof Retrofit



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Figure 44: Presentation to SPEER, September 2012 (continued)

### Performance - Application

- Coated SPF is used as a commercial roof system on this large roof - spray applied over a prepared substrate with the existing roof most often remaining in-place



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### Performance - Application

- More roofs are now applied using robotic technology



39

### Performance - Application

- SPF is coated with a UV resistant elastomeric coating providing a seamless membrane fully bonded roofing system



40

### Performance - Application

- Granules or aggregate can be applied into an additional application of coating



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### Performance - Application

- SPF creates a seamless blanket over existing roofing



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### Performance - Application

- Round stacks, vents, and curbs are easily flashed with SPF



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Figure 44: Presentation to SPEER, September 2012 (continued)

### Performance - Application

- A wall-to-roof flashing, note drains in wall



44

### Performance - Application

- This school has a beige coating with granules over the spray foam



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### Performance - Application

- Industrial facilities benefit from lightweight SPF insulation



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### Performance - Application


- Numerous national accounts have relied on SPF roofs for many years



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### Performance - Application

- SPF seals metal roof flashings



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### Performance - Application

- 29 year old dome before/after



2011 BPFE03 - SD+HSW 49

Figure 44: Presentation to SPEER, September 2012 (continued)

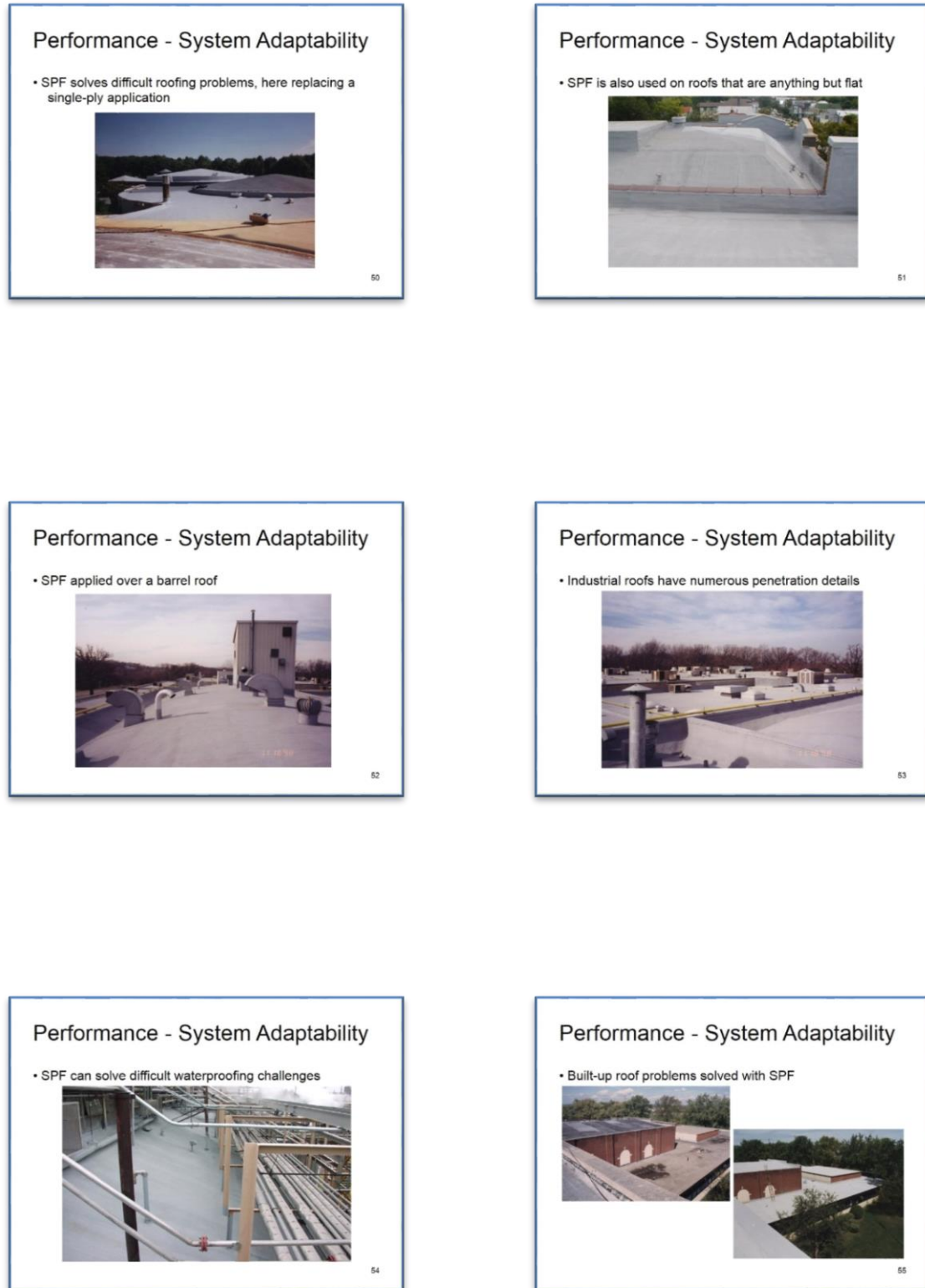


Figure 44: Presentation to SPEER, September 2012 (continued)



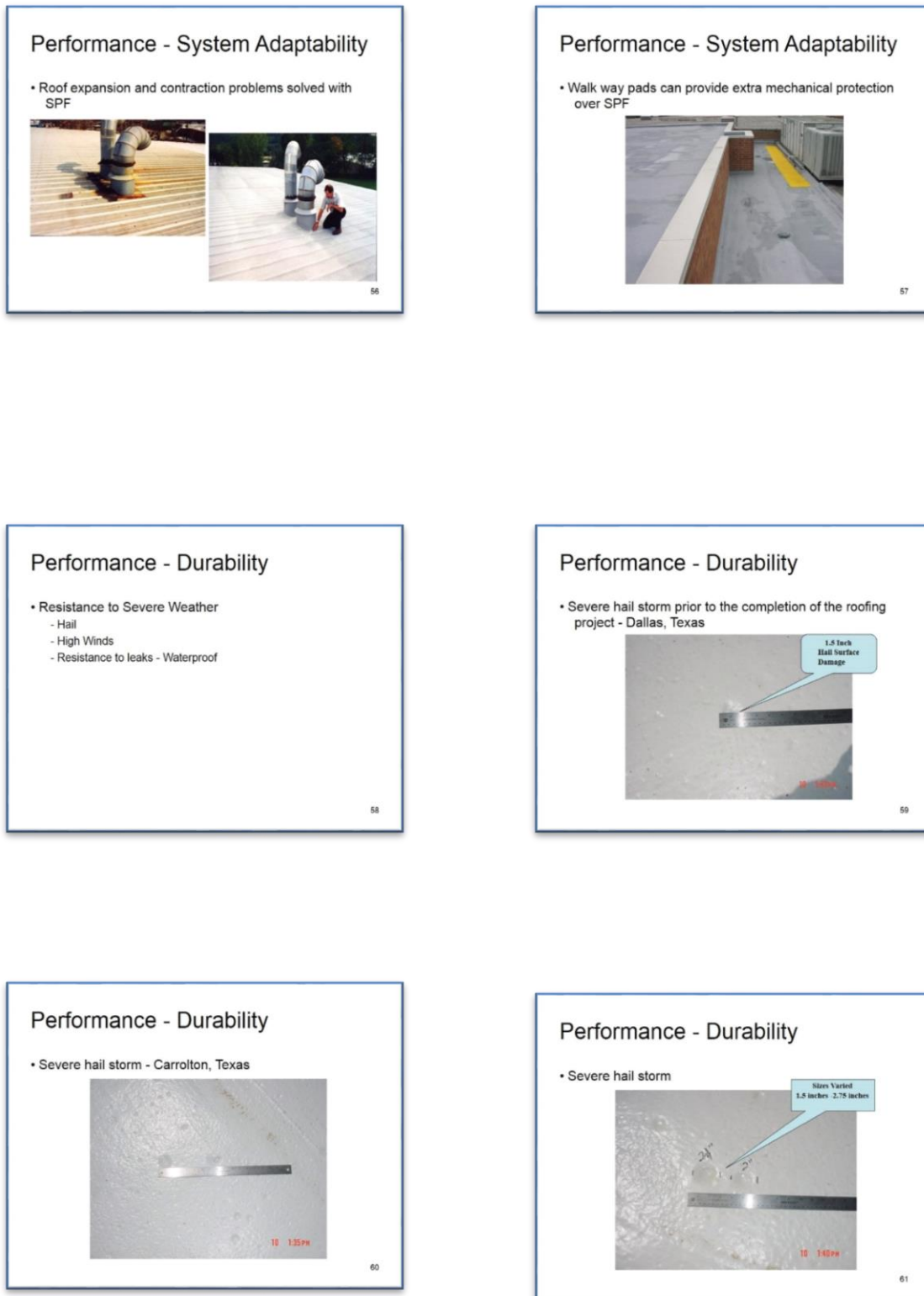


Figure 44: Presentation to SPEER, September 2012 (continued)

### Performance - Durability


- Biloxi Coliseum



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### Performance - Durability

- 16 Hurricanes and tropical storms and still standing



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### Performance - Service Life

- Renewable/Re-Coated
  - 5, 10, 15, 20 year warranties
- Long Service Life
  - Sustainability
  - Return on Investment
- Outlasts the service life of most other roofing systems

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### Performance - Service Life


- SPF roof system service life sustainability



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### Performance - Service Life

- New Orleans Super Dome roof in service since 1975



66

### Performance - Service Life

- Coated Foam Roofing provides for a long sustainable service life with the ability to recoat/renew



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Figure 44: Presentation to SPEER, September 2012 (continued)

### Performance - Service Life

- Resurface with Elastomeric Coating and granules



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### Performance - Service Life

- Fleetwood Motor Homes
- 300,000 SF 17 year old roof renewal



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### Performance - Sustainability

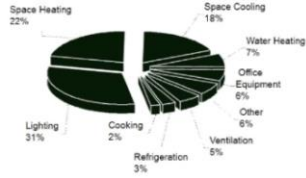
- Energy efficient SPF insulation seals this window wall construction from heat loss, and water entry



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### Environmental and Building Sustainability

- Commercial Building Energy Use



End Use	Percentage
Space Heating	22%
Lighting	21%
Space Cooling	18%
Water Heating	7%
Office Equipment	6%
Other	6%
Ventilation	5%
Refrigeration	3%
Cooking	2%

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### Environmental and Building Sustainability

- Heat Island Effect
- Urban and suburban temperatures 2 to 10°F (1 to 6°C) hotter than nearby rural areas
- Elevated temperatures can impact communities by increasing:
  - Peak energy demand
  - Air conditioning costs
  - Air pollution levels
  - Heat-related illness and mortality

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### Environmental and Building Sustainability

- EPA Study - Implications of Heat Island Effects
- Conducted by Heat Island Group
- Detailed analysis of energy-saving potentials of light-colored roofs in 11 U.S. metropolitan areas
- Approximately ten residential and commercial building prototypes simulated in each area
- Considered both savings in cooling and penalties in heating
  - Estimated saving potentials of about \$175 million per year for the 11 cities
  - Extrapolated national energy savings were about \$750 million per year

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Figure 44: Presentation to SPEER, September 2012 (continued)

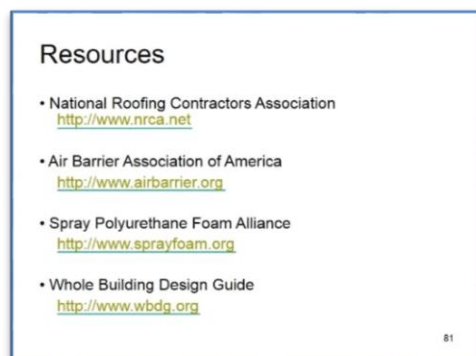
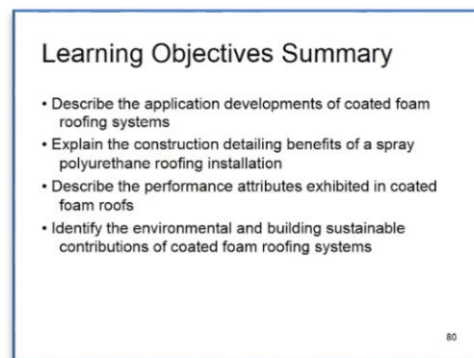
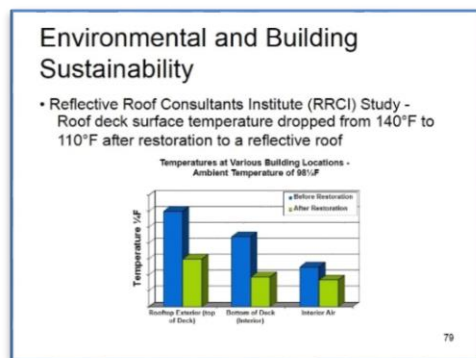
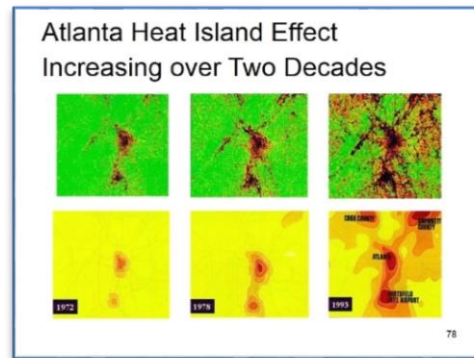
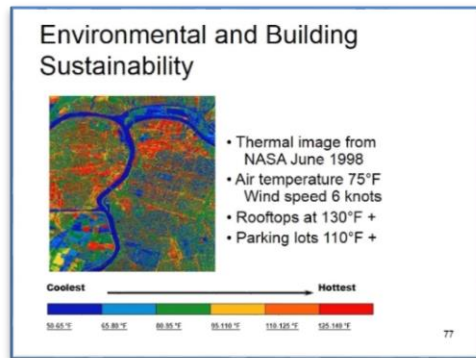


Figure 44: Presentation to SPEER, September 2012 (continued)

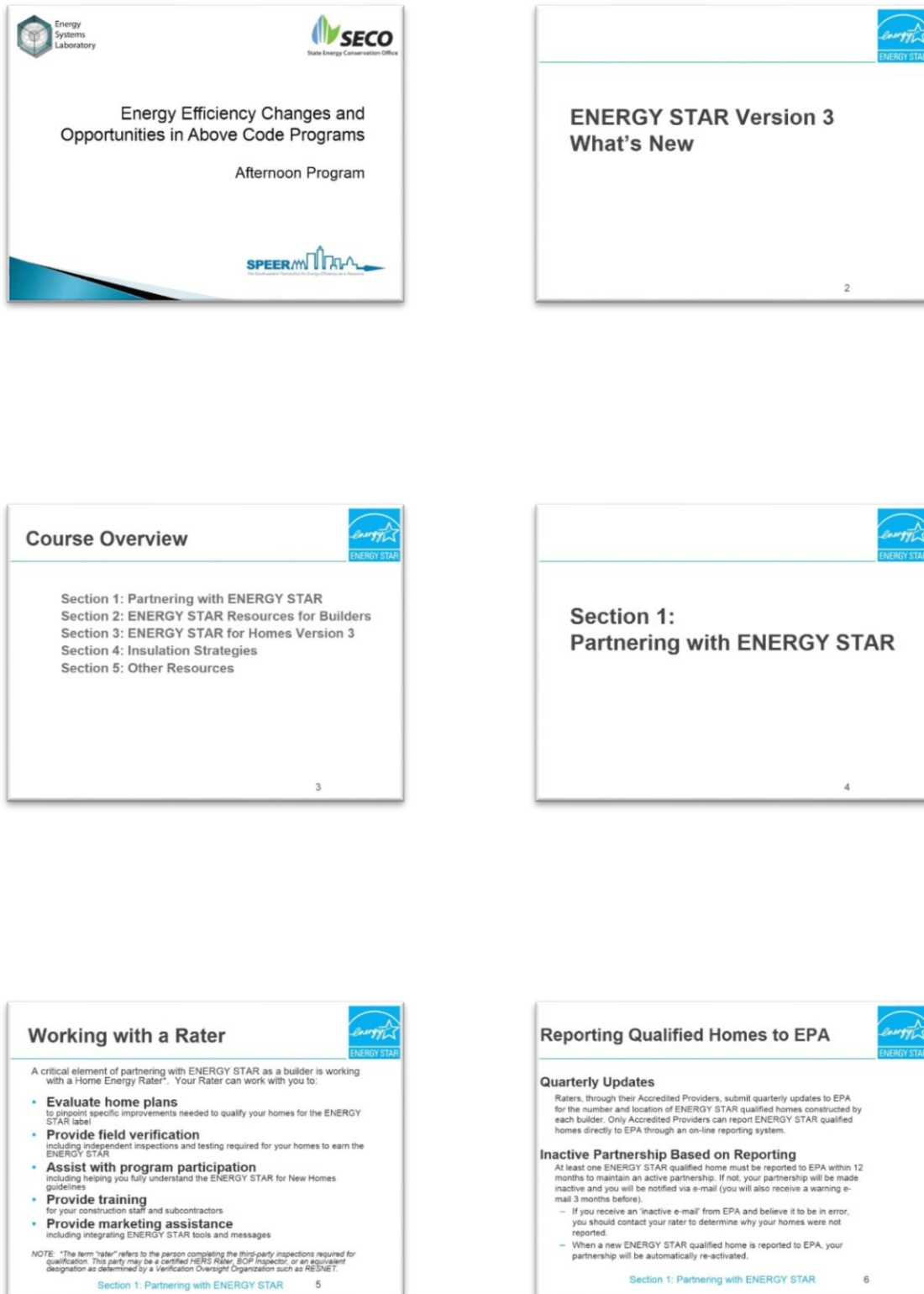



Figure 44: Presentation to SPEER, September 2012 (continued)



## ENERGY STAR Labels

- Labeling Requirement**  
ENERGY STAR builder partners must ensure that an ENERGY STAR label is completed and affixed to the circuit breaker box (or other suitable location) on all qualified homes. This is the "proof" that the home has earned the ENERGY STAR.
- Source of Labels**  
EPA provides ENERGY STAR labels to Accredited Providers for free. The Provider will distribute the completed label to your Rater or directly to you to post in the home.




Section 2: ENERGY STAR Resources 7

## Section 2: ENERGY STAR Resources for Builders

8

## ENERGY STAR Resources

- Partner Privileges**  
As an ENERGY STAR partner, you have access to a variety of resources at no cost.
- Accessing Resources**  
All resources are available on the ENERGY STAR Web site ([www.energystar.gov/homes](http://www.energystar.gov/homes)) in the "Resources for Partners" section.
- Frequently Asked Questions**  
You can also review a list of Frequently Asked Questions (FAQs) about the program at [www.energystar.gov/faqs](http://www.energystar.gov/faqs).



Section 2: ENERGY STAR Resources 9

## Marketing and Educational Resources

### Selling the value of ENERGY STAR

- Builder partners construct homes to strict EPA guidelines for energy efficiency and quality construction.
- To benefit from this commitment, you must educate prospective homebuyers about the features and benefits of your ENERGY STAR Qualified Homes.
- EPA offers a number of marketing and education resources at no charge to help.
- Visit [www.energystar.gov/homes](http://www.energystar.gov/homes) and look for the links to "Educational Resources" and "Marketing Resources."

Section 2: ENERGY STAR Resources 10

## ENERGY STAR Marks

### Brand Recognition


Over 75 percent of Americans recognize the ENERGY STAR logo as the symbol for energy efficiency. Thus, the ENERGY STAR identity is a valuable asset that must be properly used and protected.

### Brand Integrity

Ensuring that the ENERGY STAR name and logo are properly used protects all partner's investment in the program—and consumer confidence in the ENERGY STAR program.

### Brand Enforcement

Proper use of the ENERGY STAR logo is strictly enforced and must be in compliance with the ENERGY STAR Identity Guidelines (available at [www.energystar.gov/logos](http://www.energystar.gov/logos)).



Section 2: ENERGY STAR Resources 11

## Identity Guidelines

While partners should review the complete ENERGY STAR Identity Guidelines, key points include:

- Trademark Violations**  
The logos may never be associated with homes that have not been qualified as ENERGY STAR.
- Logo and Text Cannot be Changed**  
The ENERGY STAR logos may not be altered, cut apart, separated, or otherwise distorted in perspective or appearance.
- Logo Color**  
The preferred color for the mark is ENERGY STAR blue (100% Cyan), but black and white are also acceptable.
- Builder Responsibility**  
Builder partners are responsible for the proper use of the ENERGY STAR logos in all applications, including when the partner authorizes outside vendors to develop materials that use the logo on their behalf.

Section 2: ENERGY STAR Resources 12

Figure 44: Presentation to SPEER, September 2012 (continued)

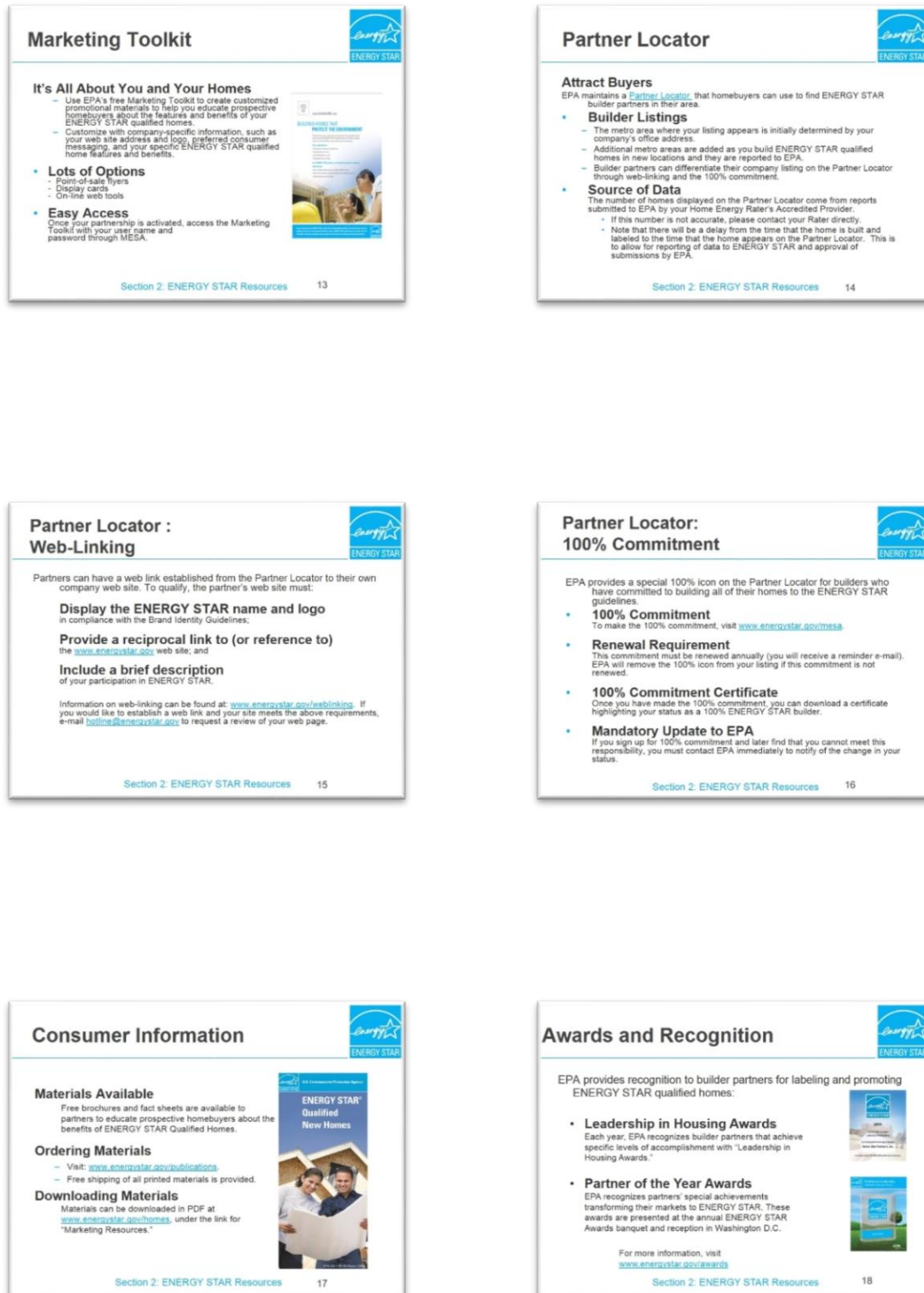


Figure 44: Presentation to SPEER, September 2012 (continued)

**Section 3:  
ENERGY STAR for Homes Version  
3**

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**ENERGY STAR Version 3:  
Background**

**Time for Change:**

In 2010, EPA released new guidelines for homes to earn the ENERGY STAR label (referred to as 'Version 3'). These were developed in response to critical external forces:

- As new national and regional energy codes were rapidly increasing, new guidelines were needed to ensure that ENERGY STAR qualified homes continued to represent a meaningful improvement in energy efficiency over homes built to code and standard building practices.
- Augmenting the guidelines with cost-effective energy efficiency technologies and building science practices will help improve home efficiency, durability, and indoor air quality of ENERGY STAR qualified homes.

Section 3: ENERGY STAR for Homes Version 3 20

**ENERGY STAR Version 3:  
Resources**

**Technical Resources**

Field guides and technical presentations have been developed to help builders successfully implement the requirements of ENERGY STAR for Homes Version 3.

**Where to Find Resources**

All Version 3 documents are available at [www.energystar.gov/homes](http://www.energystar.gov/homes) under 'Guidelines and Technical Resources'.

Section 3: ENERGY STAR for Homes Version 3 21

**ENERGY STAR Version 3:  
Major Changes**

**Variable vs. Fixed HERS Score**

Instead of a fixed HERS Score, a variable HERS Index Target Score is calculated for each home by applying a set of specifications called the ENERGY STAR Reference Design.

**Renewables**

Unlike Version 2 of the guidelines, you can take credit for renewable energy systems, but only to help large homes meet the additional efficiency required by the Size Adjustment Factor.

Section 3: ENERGY STAR for Homes Version 3 22

**ENERGY STAR Version 3:  
Major Changes**

**Size Adjustment Factor**

- Homes larger than the average size for a specified number of bedrooms (called the 'Benchmark Home Size') must apply a Size Adjustment Factor that will reduce the ENERGY STAR HERS Index Target. This will increase the energy efficiency requirements for larger homes.
- Bedrooms and floor area in basements that are mostly below grade are excluded when determining a home's Benchmark Home Size, comparing the home against the Benchmark Home Size, and calculating the Size Adjustment Factor.

Section 3: ENERGY STAR for Homes Version 3 23

**ENERGY STAR Version 3:  
Major Changes**

**Variable vs. Fixed HERS Score**

Instead of a fixed HERS Score, a variable HERS Index Target Score is calculated for each home by applying a set of specifications called the ENERGY STAR Reference Design.

**Checklists**

To earn the ENERGY STAR label, all homes must now be inspected for compliance with a new set of checklists.

- Two checklists are to be completed by the Home Energy Rater.
- One checklist by your HVAC contractor, and
- One checklist by you, the builder.

Section 3: ENERGY STAR for Homes Version 3 24

Figure 44: Presentation to SPEER, September 2012 (continued)

## ENERGY STAR Version 3: Overview

Under the new guidelines, homes earn the ENERGY STAR meeting a combination of core energy efficiency measures and mandatory inspection checklists.

### Inspection Checklists

The mandatory inspection checklists ensure that additional building science features are included in qualified homes.

Section 3: ENERGY STAR for Homes Version 3 25

## ENERGY STAR Version 3: Overview

The core energy efficiency features can be met using either:

- **Prescriptive Path**
  - The home is designed and built to a pre-defined set of specifications (called the "ENERGY STAR Reference Design") for the climate where the home will be built. No trade-offs are allowed.
  - The ENERGY STAR Reference Design provides efficiency requirements for the building envelope, HVAC and water heating equipment, lighting, and appliances.
  - Only homes the same or smaller than their corresponding Benchmark Home may use this path.
- **Performance Path**
  - A rater models the home to establish an ENERGY STAR HERS Index Target for the home. For homes larger than their Benchmark Home, this ENERGY STAR HERS Index Target will take into account the Size Adjustment Factor.
  - The builder then has the flexibility to select a custom set of energy-efficiency measures to earn the ENERGY STAR label for the home, so long as the home's HERS Index Target threshold is met or exceeded.

Section 3: ENERGY STAR for Homes Version 3 26

## Qualifying Homes Under Version 3

1. Check eligibility.
2. Check Benchmark Home Size.
3. Select Version 3 energy efficiency measures.

Prescriptive Path	Performance Path	
1. Build the home using the ENERGY STAR Reference Design.	1. Model the home and create the ENERGY STAR Reference Home.	These steps are new and will be performed by your rater.
2. Complete the inspection checklists.	2. If the home is larger than the Benchmark Home Size, apply the Size Adjustment Factor to find the ENERGY STAR HERS Index Target.	
	3. Select upgrades that meet the mandatory requirements and achieve a HERS Index $\leq$ ENERGY STAR HERS Index Target.	These steps are the same as under Version 2.
	4. Complete the inspection checklists.	

Section 3: ENERGY STAR for Homes Version 3 28

## Using the Prescriptive Path

Homes can be qualified through the Prescriptive Path when:

- The home is the same size or smaller than the Benchmark Home Size;
- The home has been designed and constructed to the ENERGY STAR Reference Design with no trade-offs; and
- The home passes all required tests and meets the requirements of the Inspection Checklists.

Section 3: ENERGY STAR for Homes Version 3 28

## Using the Performance Path

The ENERGY STAR Reference Home is used to set the performance threshold that each home qualified under the Performance Path must meet. This threshold is called the ENERGY STAR HERS Index Target.

Your rater will configure a customized ENERGY STAR Reference Home for the home you want to build.

Section 3: ENERGY STAR for Homes Version 3 29

## Using the Performance Path

If the home you want to build is larger than the Benchmark Home Size, they will apply a Size Adjustment Factor. The Benchmark Home Size is defined by the table below:

Bedrooms	1	2	3	4	5	6	7	8
CFA	1,000	1,600	2,200	2,800	3,400	4,000	4,600	5,200

Remember that bedrooms and square footage in basements that are mostly below-grade are not counted when finding the Benchmark Home Size.

Your rater will use the ENERGY STAR Reference Home and the Size Adjustment Factor to create an ENERGY STAR HERS Index Target. This is the performance threshold that the home you want to build must meet to earn the ENERGY STAR.

Section 3: ENERGY STAR for Homes Version 3 30

Figure 44: Presentation to SPEER, September 2012 (continued)

### Performance Path Compliance

- Select upgrades**  
 The builder has the flexibility to select a custom set of energy efficiency specifications, so long as the resulting HERS Index meets or exceeds the ENERGY STAR HERS Index Target and other requirements (e.g., minimum efficiency for windows, insulation) are met.
- Verification**  
 The home must be designed and constructed to the customized specifications and pass all required inspections and testing.

Section 3: ENERGY STAR for Homes Version 3 31

### ENERGY STAR Version 3: HERS Rater Checklists

Checklists to be completed by your Home Energy Rater:

- Thermal Enclosure System Rater Checklist**
  - This checklist is designed to ensure that the exterior building shell/envelope of ENERGY STAR qualified homes are optimized for efficiency and durability.
  - This checklist replaces the Thermal Bypass Checklist that was part of the last ENERGY STAR for Homes guidelines.
- HVAC Quality Installation Rater Checklist**
  - This checklist is used to verify that the home's ductwork and ventilation system have been installed properly, and provides additional validation of HVAC contractors' work.

Section 3: ENERGY STAR for Homes Version 3 32

### ENERGY STAR Version 3: HVAC Contractor Checklist

Checklist completed by your HVAC Contractor:

- HVAC Quality Installation Contractor Checklist**
  - This checklist ensures that the heating and cooling systems in ENERGY STAR qualified homes are designed and installed according to industry-accepted quality installation practices.
  - Only HVAC contractors who have demonstrated the requisite skills and capabilities to perform HVAC Quality Installations will be permitted to complete this checklist.
  - To ensure that your HVAC contractor is credentialed, you can refer to a list provided through the ENERGY STAR Web site.

Section 3: ENERGY STAR for Homes Version 3 33

### ENERGY STAR Version 3: Builder Checklist

**Water Management System Builder Checklist**

- This checklist requires an inspection of key areas of ENERGY STAR qualified homes to help assure bulk moisture control, including water-managed foundation, walls, roofs, and building materials.
- This checklist must be completed by the site supervisor or other qualified individual on the builder's staff.
- Your Rater may also verify items on the checklist; however, you as the builder are responsible for accuracy of all checklist requirements.
- Completed and signed checklist should be provided to your Home Energy Rater to keep with the home's ENERGY STAR file.
- As an alternative to completing this checklist, the house can be qualified under EPA's [Indoor airPLUS program](#).

Section 3: ENERGY STAR for Homes Version 3 34

### Special Considerations

When local codes or manufacturer's guidance meet or exceed ENERGY STAR requirements, the more rigorous requirements must be met.

When codes or manufacturer's guidance conflicts with ENERGY STAR requirements, work with your rater to determine if there's an alternate way to achieve the intent of the ENERGY STAR requirement. If there is no equivalent option, then the ENERGY STAR requirement can be waived and the home can still be qualified.

Section 3: ENERGY STAR for Homes Version 3 35

### Section 4. Insulation Strategies

- Innovative insulating & wall assembly strategies**
  - Typical assembly
  - New innovations
    - Features & benefits of each

Figure 44: Presentation to SPEER, September 2012 (continued)




### Typical Site Built Residential Wall

**Concept:**  
• Site built wood frame wall with exterior sheathing and batt insulation

**Components:**

- Exterior Finish (bulk moisture control)
- Building wrap
- Exterior sheathing
- 2x4 Studs @ 16" O.C.
- Batt Insulation (+/- 3.7 R per inch)
- Gypsum board

**Benefits:**  
• Relatively low cost

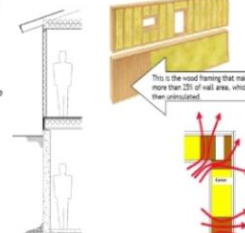


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### Typical Site Built Residential Wall

**Key performance deficiencies**

- Low effective R-value
- Difficulty meeting IECC 2012 R-value requirements with 2x4 stud cavity
- Thermal bridging due to non-continuous insulation
- Air leakage points
- No vapor control layer



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### Innovative Solutions

#### Structural Insulated Panels (SIP)


**Concept:**  
• EPS or Polyurethane sandwiched between sheathing to create a highly insulated wall

**Components:**

- Moisture barrier/control layer
- Wood sheathing
- Rigid foam insulation core
- EPS - R-3 to R-4.5 per inch
- or
- Closed cell spray foam insulation - R-6 to R-7 per inch
- 2x4 or 2x6 Studs

**Benefits:**

- R-value increases with thickness of SIP
- Minimal thermal bridging
- Panelization creates labor and construction cycling benefits
- Can achieve R-21 to R-55 in the whole assembly



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### Structural Insulated Panels (SIP)

**Key Performance Metrics**

- **Code & Above Compliance:**
  - Can meet wall insulation requirements for all climate zones at 4 inch thickness
- **Key Control Layer Placement:**
  - Thermal - rigid insulation
  - Vapor - exterior finish
  - Bulk moisture - exterior cladding
  - Air - rigid insulation
- **Applicability per climate Zone:**
  - Suitable for all climate zones

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### Innovative Solutions

#### Insulated Concrete Forms (ICF)

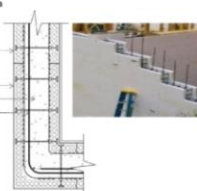
**Concept:**  
• EPS blocks are together and filled with concrete to create a highly insulated wall

**Components:**

- Exterior Finish
  - Moisture barrier
- Rigid foam insulation, R-3 to R-4.5 per inch
- Concrete
- Rebar

**Benefits:**

- High R-value increases with thickness of ICF
- High resistance to severe weather/ high wind speeds
- Potential for HVAC equipment size reduction



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### Insulated Concrete Forms (ICF)

**Key Performance metrics**

- **Code & Above Compliance:**
  - Meets wall insulation requirements for all climate zones
- **Key Control Layer Placement:**
  - Thermal - rigid insulation
  - Vapor - exterior finish
  - Bulk moisture - exterior finish
  - Air - exterior finish
- **Applicability per climate Zone:**
  - Suitable for all climate zones

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Figure 44: Presentation to SPEER, September 2012 (continued)

### Innovative Solutions

#### Hybrid cavity with continuous exterior insulation

**Concept:**

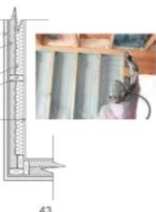
- Typical site built stud wall with a flash coat of closed cell SPF in the cavity, and your favorite fibrous insulation filling the rest of the cavity

**Components:**

- Insulated exterior sheathing
  - Integral moisture control layer
  - Separate moisture control layer
- Closed cell SPF
  - 1-2 inches @ R-6.7 per inch
- Air permeable insulation, avg 3.7 R per inch
- 2x4 or 2x6 Studs
- Gypsum board

**Benefits:**

- Reduced air infiltration due to air sealing properties of spray foam
- SPF can be vapor permeable or a vapor barrier depending on thickness
- Increased R-value without significantly increased depth
- Potential for HVAC equipment size reduction
- Suitable for walls and ceilings



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### Hybrid insulation wall

#### Key performance metrics

- Code & Above Compliance:**
  - Meets insulation requirements for all climate zones using 2x4 construction
- Key Control Layer Placement:**
  - Thermal- High density foam, air permeable insulation
  - Vapor- Joint sealed exterior continuous insulation
  - Bulk moisture- exterior cladding
  - Air- Closed cell SPF, Joint sealed exterior continuous insulation
- Applicability per climate Zone:**
  - Suitable for all climate zones

44

## Section 5: Other Resources

45

### Other EPA programs

- EPA Indoor airPLUS**  
This label recognizes new homes equipped with a comprehensive set of Indoor Air Quality features.
  - Indoor airPLUS verification can be completed by your Home Energy Rater during the ENERGY STAR verification process.
  - Builders participating in the Indoor airPLUS program do not need to complete the ENERGY STAR Water Management System Builder Checklist.
  - For more information, visit [www.epa.gov/indoorairplus](http://www.epa.gov/indoorairplus)
- EPA WaterSense**  
This label is for new homes designed to reduce residential water use indoors and outdoors, compared to typical new homes.
  - For more information and to become a partner, visit [www.epa.gov/watersense](http://www.epa.gov/watersense).

Section 5: Other Important Resources 46

### ENERGY STAR Qualified Manufactured Homes

- Manufactured Homes**
  - There are specialized ENERGY STAR guidelines and 3<sup>rd</sup> Party verification procedures for manufactured homes
  - Manufacturing plants must first be certified to produce ENERGY STAR qualified manufactured homes
  - A site installation checklist must be completed for every home before it earns the ENERGY STAR label.
  - For more information visit: [http://www.energystar.gov/index.cfm?c=bldgs\\_lenders\\_raters\\_pt\\_builder\\_manufactured](http://www.energystar.gov/index.cfm?c=bldgs_lenders_raters_pt_builder_manufactured)

Section 5: Other Important Resources 47

### ENERGY STAR Qualified Modular Homes

#### Modular Homes

- Must meet the same ENERGY STAR guidelines as site-built homes
- Two independent third-party verification options:
  - Conventional HERS Rating with field verification
  - Alternate verification process where modules provided by a plant qualified to produce ENERGY STAR qualified modular homes and a site inspection by a Home Energy Rater (note different reporting and labeling procedures for this verification process)
- For more information visit: [http://www.energystar.gov/index.cfm?c=bldgs\\_lenders\\_raters\\_homes\\_guidelines\\_modular](http://www.energystar.gov/index.cfm?c=bldgs_lenders_raters_homes_guidelines_modular)

Section 5: Other Important Resources 48

Figure 44: Presentation to SPEER, September 2012 (continued)

## Questions about Tax Credits or Financing?



The best place to find information about energy efficiency tax credits is [www.energystar.gov/taxcredits](http://www.energystar.gov/taxcredits).

- Note that there are currently no Federal tax credits tied specifically to ENERGY STAR qualified homes (with the exception of manufactured homes).

For information about special financing available to buyers of ENERGY STAR qualified homes, visit [www.energystar.gov/mortgages](http://www.energystar.gov/mortgages).

Section 5: Other Important Resources 49




## THANK YOU!

- Christopher Little, Senior Advisor, Center for Building Excellence
  - Email: [Chris.Little@BASF.com](mailto:Chris.Little@BASF.com)



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Figure 44: Presentation to SPEER, September 2012 (continued)



Figure 44: Presentation to SPEER, September 2012 (continued)



Figure 44: Presentation to SPEER, September 2012 (continued)



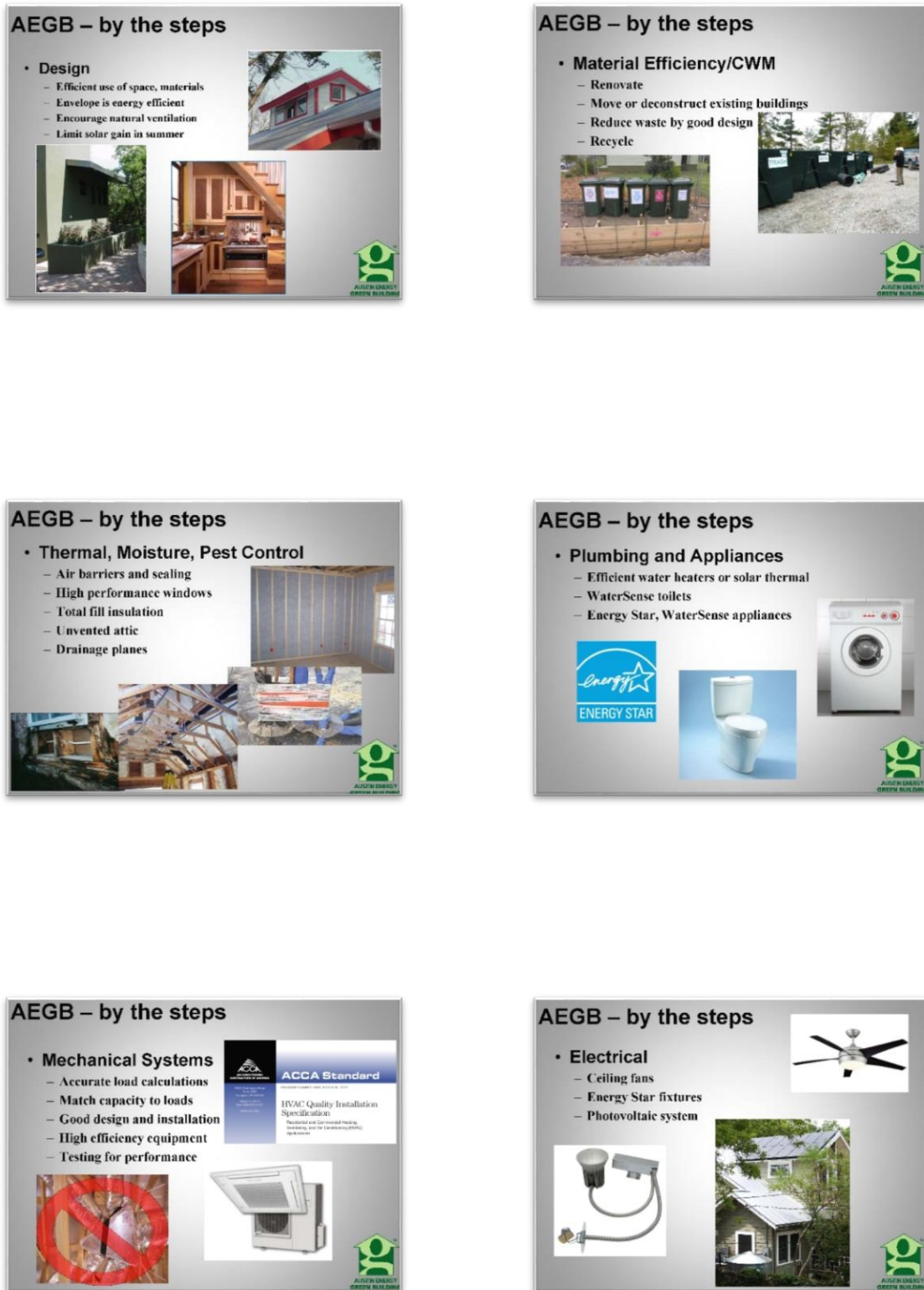


Figure 44: Presentation to SPEER, September 2012 (continued)

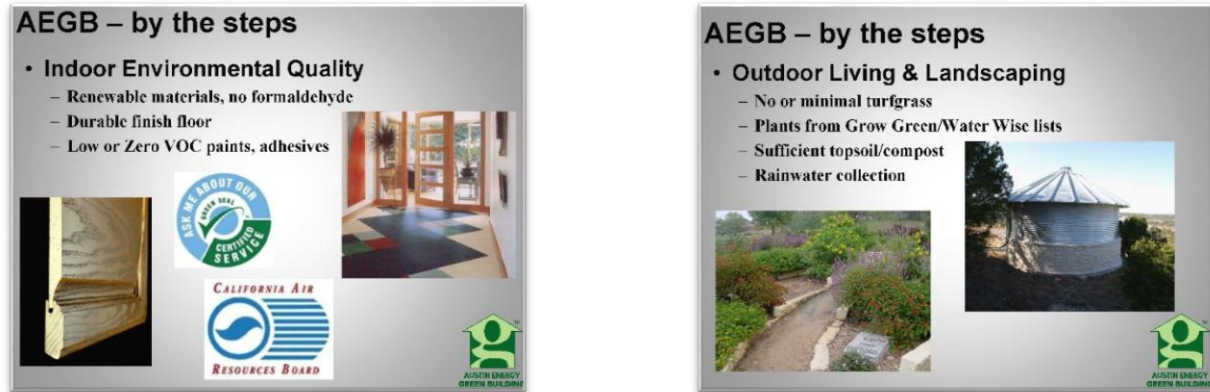


Figure 44: Presentation to SPEER, September 2012 (continued)



Figure 44: Presentation to SPEER, September 2012 (continued)

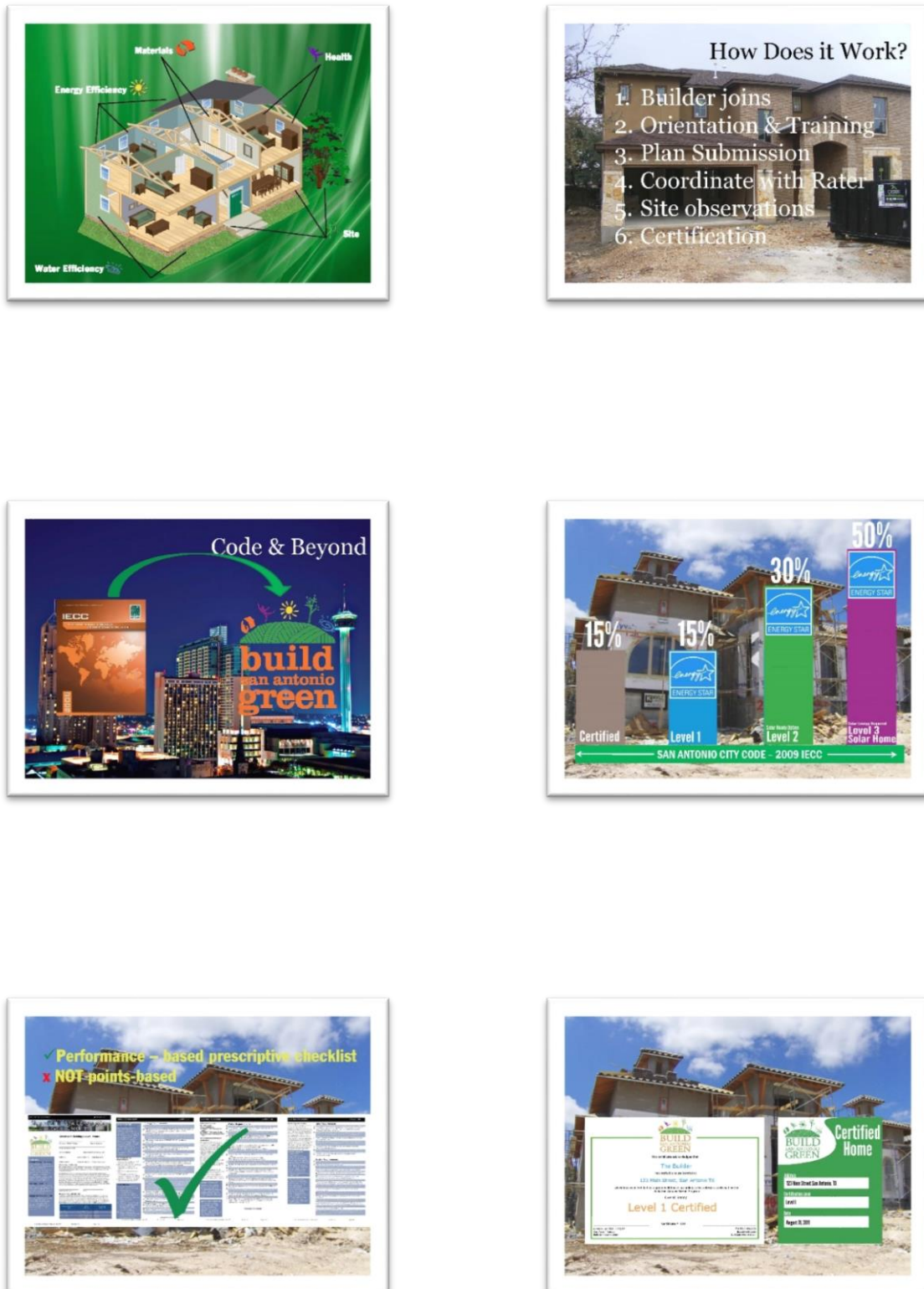


Figure 44: Presentation to SPEER, September 2012 (continued)





Figure 44: Presentation to SPEER, September 2012 (continued)



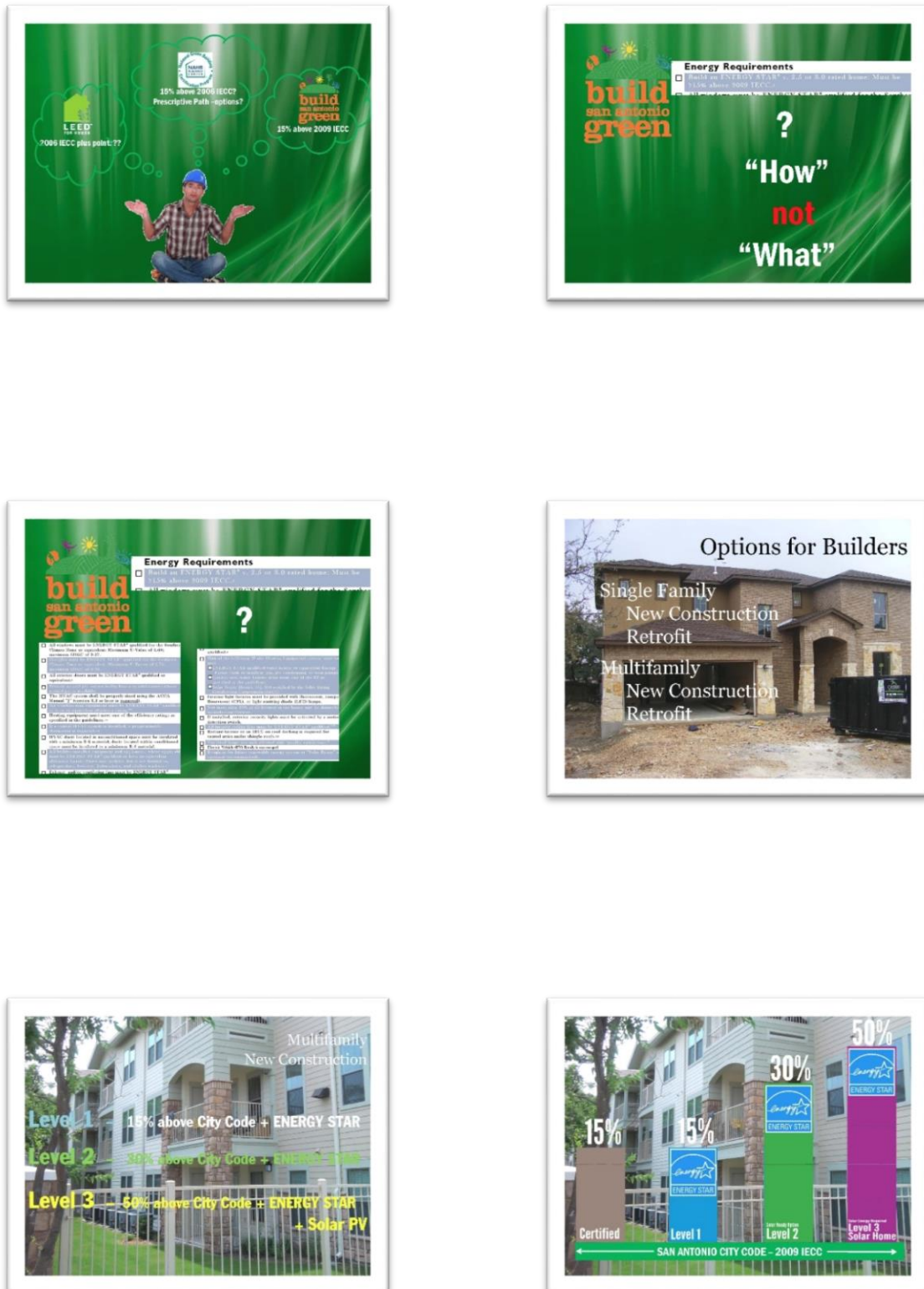


Figure 44: Presentation to SPEER, September 2012 (continued)

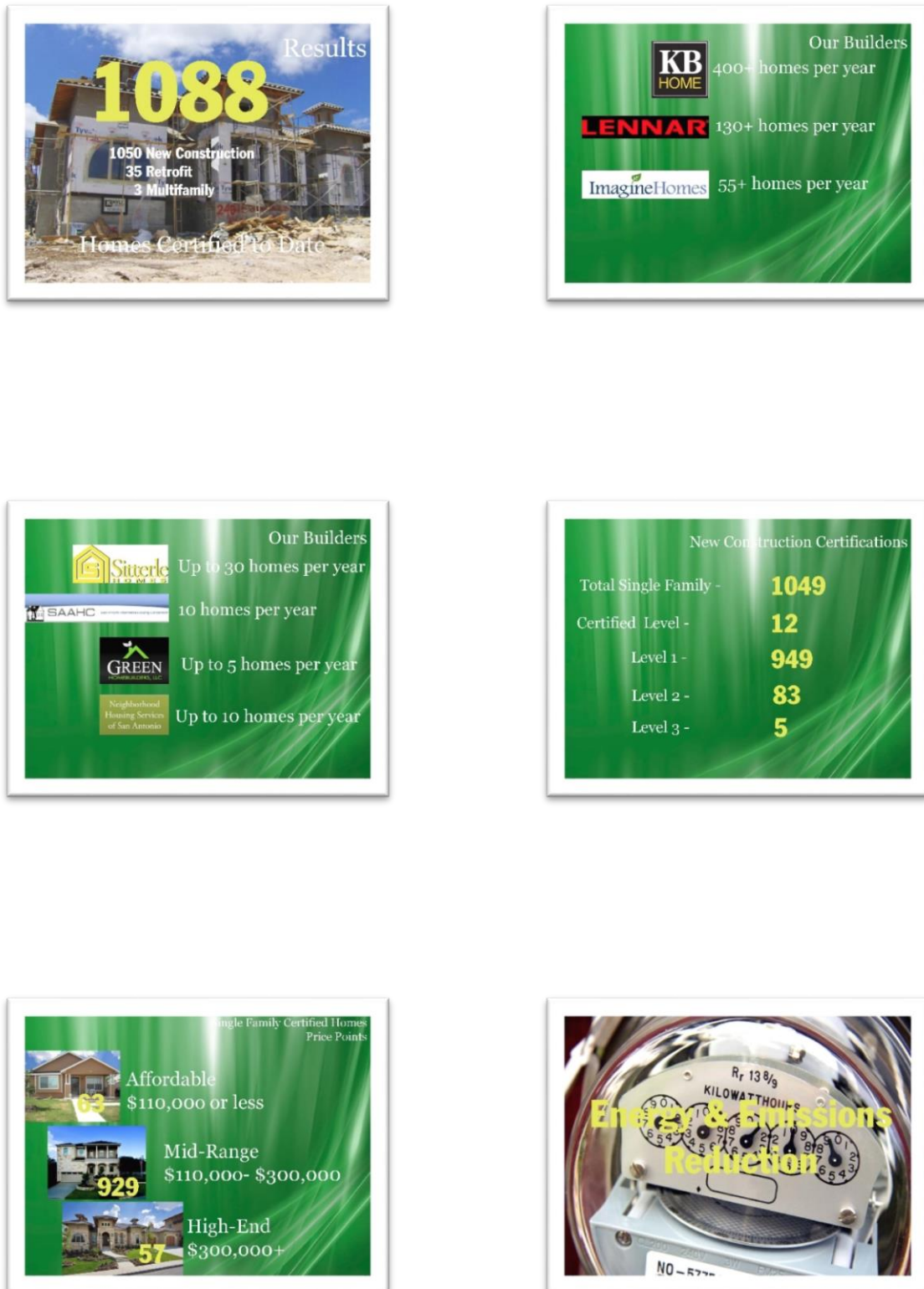


Figure 44: Presentation to SPEER, September 2012 (continued)

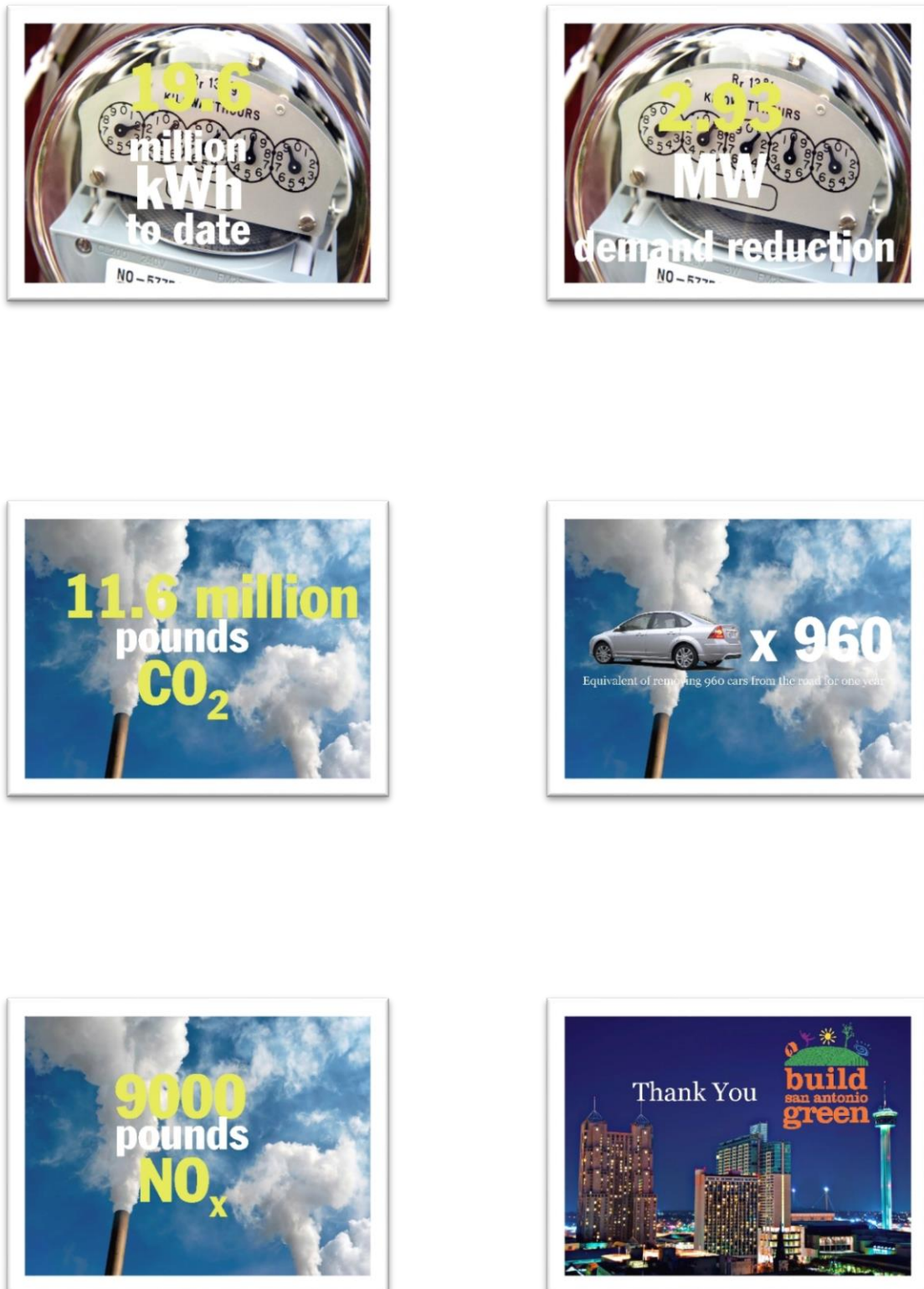


Figure 44: Presentation to SPEER, September 2012 (continued)



## Presentation to SPEER, October 2012

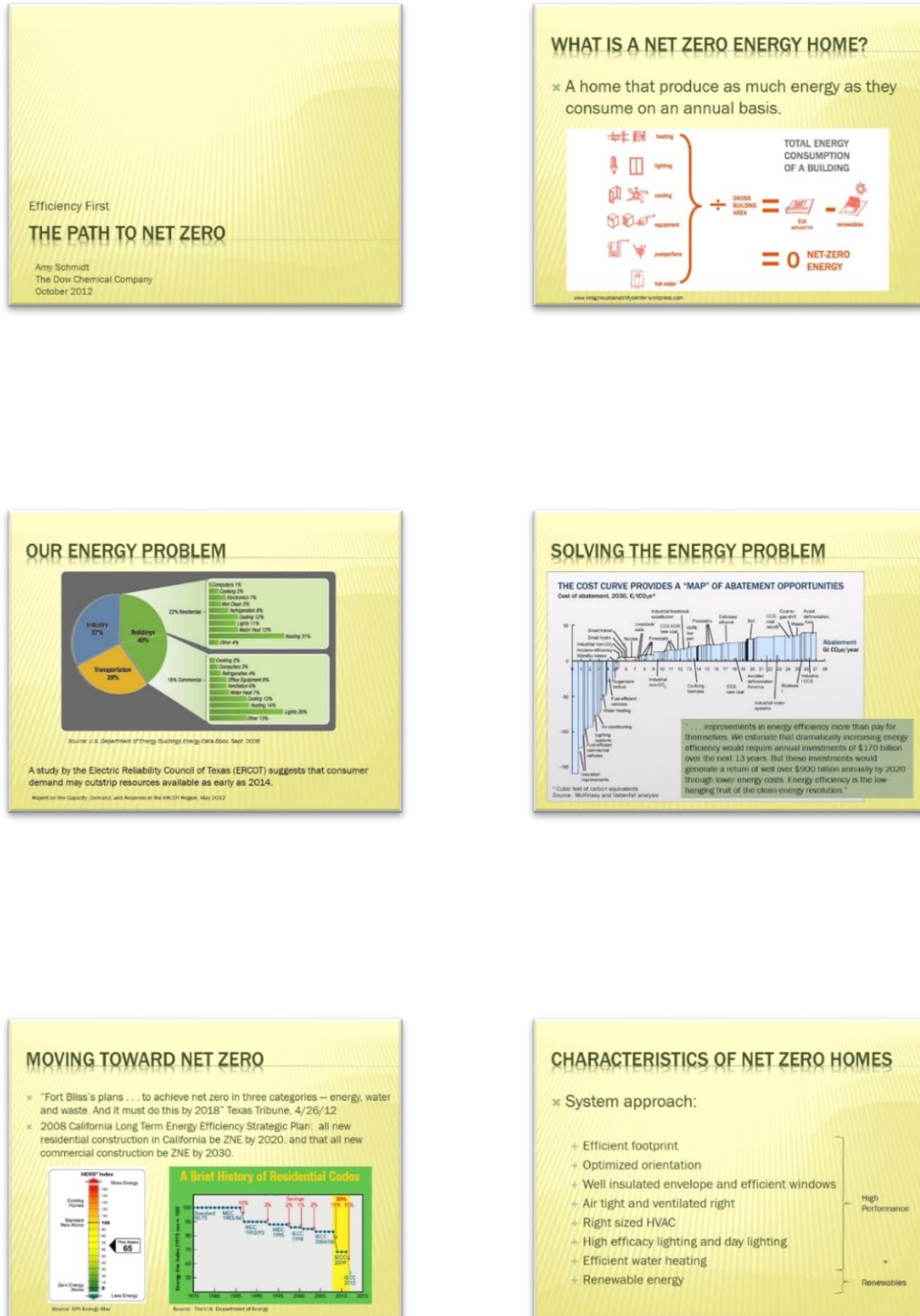


Figure 45: Presentation to SPEER, October 2012 (continued)



Figure 45: Presentation to SPEER, October 2012 (continued)



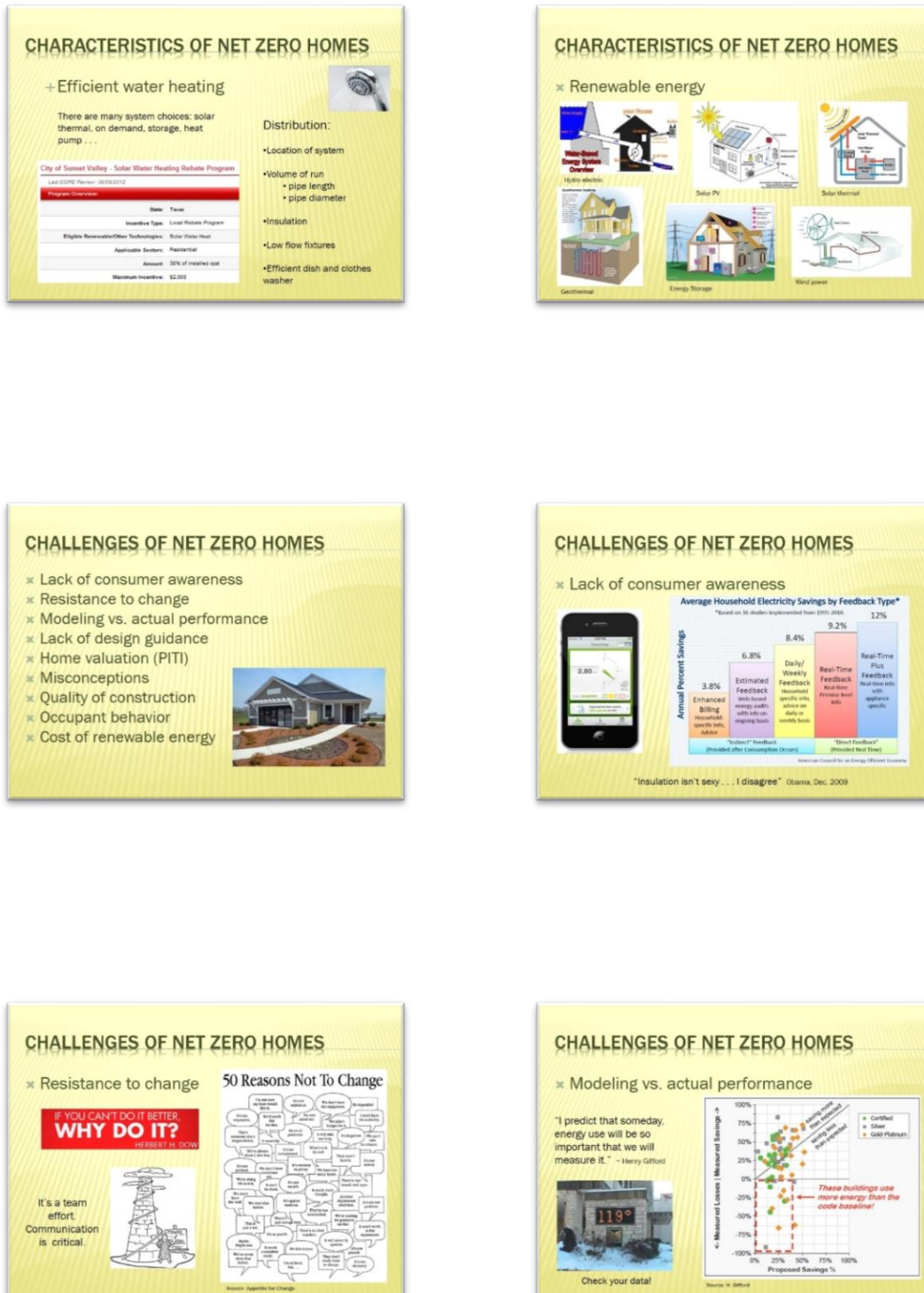


Figure 45: Presentation to SPEER, October 2012 (continued)

# CHALLENGES OF NET ZERO HOMES

- ✱ Lack of design guidance

"Results from this lab will show if net-zero technologies are ready for a neighborhood near you" — Garagrner, NCS

Building America  
Solution Center  
launching Dec. 2012  
[www.1eere.energy.gov/buildings/](http://www.1eere.energy.gov/buildings/)

Last year, we built Michigan's first Net Zero Energy Home, changing mindsets about energy efficiency. In 2011, we've done it again.



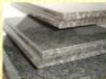


Sustainable is Affordable — InVision Zero, 2011

# CHALLENGES OF NET ZERO HOMES

- × Home valuation (PITI)

Change the equation: PITIE = Principle + Interest + Taxes + Insurance + **Energy**



"PITI absolutely misrepresents the situation. For many homeowners, Energy is the top cost after PI (principal & interest) payments, frequently larger than property taxes and is almost uniformly larger than that last I (insurance)."

Source: Best Energy 1000

# CHALLENGES OF NET ZERO HOMES

- ✖ Misconceptions




VS.




# CHALLENGES OF NET ZERO HOMES


- ✖ Quality of construction
  - Educate contractors
  - Provide mock up of proper detailing
  - Inspect
  - Test



Source: GreenSource



Source: HNTB



IF ALL ELSE FAILS  
LOWER YOUR STANDARDS

[illegible]

# CHALLENGES OF NET ZERO HOMES

+ Cost of renewable energy

## Efficiency First!

Renewable energy systems are more expensive than efficiency. Make the home as efficient as you can and then add a smaller less expensive system to take it to NZE.



[www.dsireusa.org](http://www.dsireusa.org)

Figure 45: Presentation to SPEER, October 2012 (continued)

### BENEFITS OF NET ZERO HOMES

- ✧ Lowered cost of home ownership
- ✧ Greater comfort
- ✧ Reduced need for new power generation
- ✧ Environmental stewardship
- ✧ Energy independence and security



### BENEFITS OF NET ZERO HOMES

- ✧ Lowered cost of home ownership

Table 2. Impacts to Consumer's Cash Flow from Compliance with the 2012 IECC Compared to the 2009 IECC

	Consumer's Cash Flow (Average)	2012 IECC
A	Down payment and other up-front costs	\$107
B	Annual energy savings (year one)	\$250
C	Annual mortgage increase	\$96
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	\$5
E = (B)-(C)+(D)	Net annual cash flow savings (year one)	\$150
F = (A)/E	Years to positive savings, including up-front cost impacts	2

Moving to the 2012 IECC from the 2009 IECC is cost-effective over a 30-year life cycle. On average, Texas homeowners will save \$3,456 with the 2012 IECC.

Source: U.S. Department of Energy

### BENEFITS OF NET ZERO HOMES

- ✧ Greater comfort

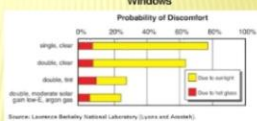
Right sized equipment results in smaller temperature swings.

ASHREA Standard 55, Thermal Environmental Conditions for Occupancy

- Temperature
- Thermal radiation
- Air speed

**Windows**

Probability of Discomfort



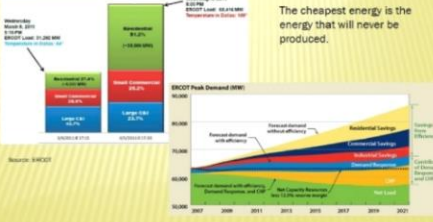
Source: Lawrence Berkeley National Laboratory (LBNL and ASHRAE)

Insulation plus air sealing results in fewer comfort complaints, better noise control, less condensation, greater durability and reduced costs.

### BENEFITS OF NET ZERO HOMES

- ✧ Reduced need for new power generation

The cheapest energy is the energy that will never be produced.

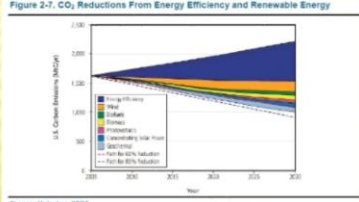


Source: NREL

### BENEFITS OF NET ZERO HOMES

- ✧ Environmental stewardship

Figure 2-7. CO<sub>2</sub> Reductions From Energy Efficiency and Renewable Energy

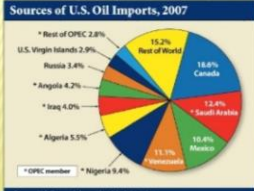


Source: Rubicher 2007

### BENEFITS OF NET ZERO HOMES

- ✧ Energy independence and security

Sources of U.S. Oil Imports, 2007



Source: U.S. Energy Information Administration




Figure 45: Presentation to SPEER, October 2012 (continued)

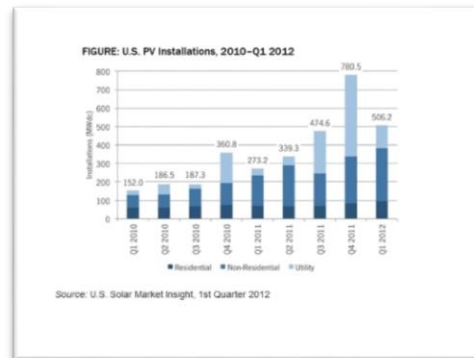
  
**DPH Consulting LLC**  
A proactive approach to building codes and standards  
  
**Darrel P. Higgs**  
  
 Net Zero Energy Requires  
 Innovative Solutions for Residential PV

**Objective**

- 1. Recognize that Solar will become an integral part of Net Zero Energy building and design.**
- 2. How traditional PV technology differs from BIPV**
- 3. Understand BIPV technology and related Codes and Standards.**

**Agenda**

- Residential PV Market
- Residential Solar Solutions
- BIPV Innovative Solutions
- Solar Codes and Standards
- Key Code and Standards Organization
- Certifications
- Summary




**What Does the Market Need?**  
 Navigating the Challenges to Residential Solar Leads to Great Solutions

Aesthetics • Complexity • Roof Integrity • Cost




**Residential Solar Solutions**

**BIPV**  
Building Integrated  
PV Solar Shingles



BIPV solar products are designed to serve as the roof.

**BAPV**  
Building Applied  
PV Solar Panels



BAPV solar products are designed to be attached to a roof.

Figure 45: Presentation to SPEER, October 2012 (continued)



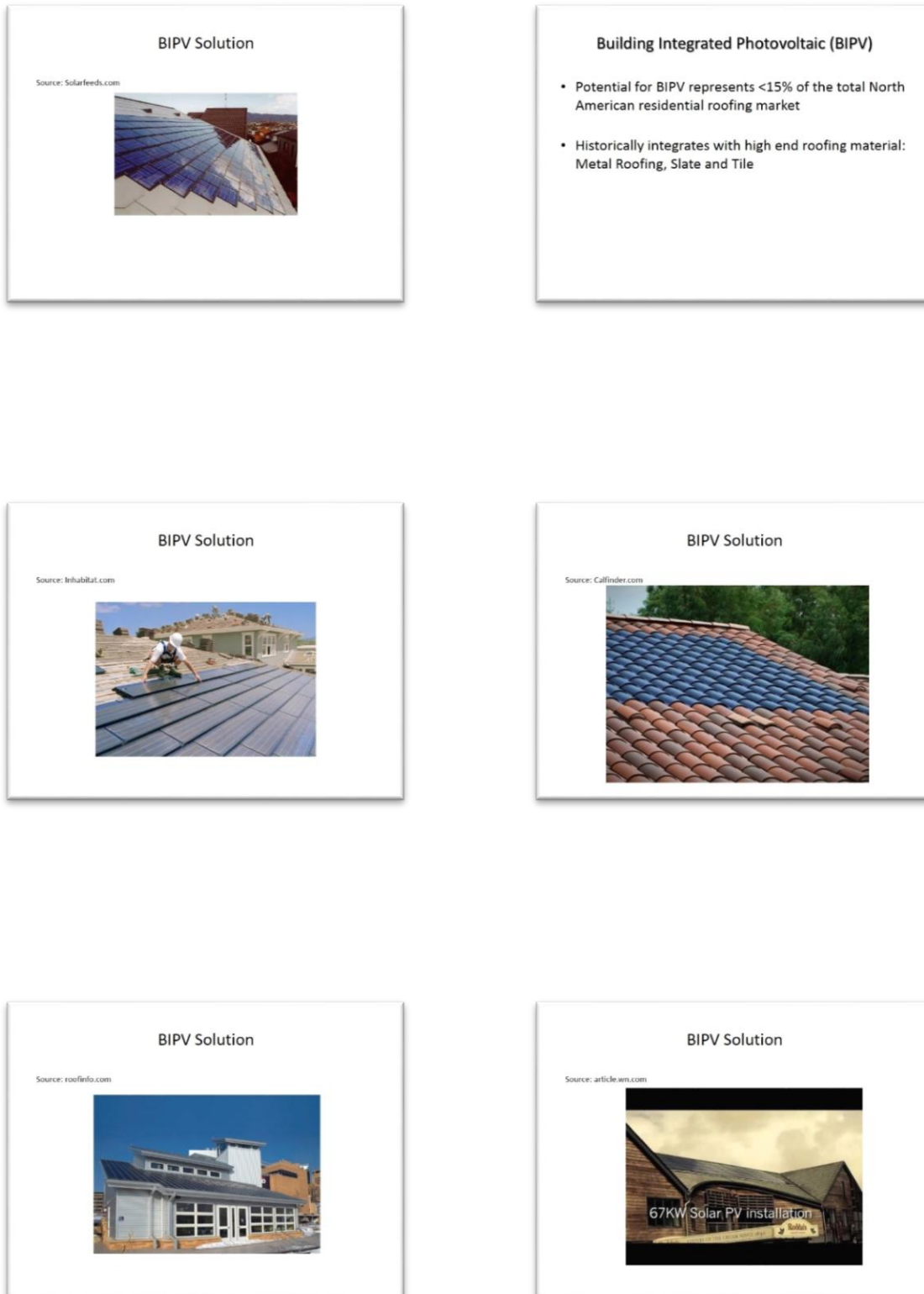



Figure 45: Presentation to SPEER, October 2012 (continued)




### BIPV & BAPV Solution

Source: solar.callfinder.com



### BIPV Solution

Source: cascadejoinery.com





### Residential Solar Challenges


- High installation costs can take years to see paybacks
- "Added on" appearance
- Complicated wiring system and installation on top of existing roof
- Customer concerns about roof integrity



### BIPV Provides Solutions

<b>Aesthetics</b>	➤ Fully integrated into the roof			
<b>Installation</b>	➤ Roof friendly ease of installation			
<b>Cost</b>	➤ Reduced installed cost that is competitive with other forms of energy			
<b>Building Codes &amp; Standards</b>	➤ Meets same wind and fire codes as conventional roof coverings			

### Aesthetics



Residential BAPV Applications

### Residential Solar Misconceptions

Going Solar = Compromised Home Aesthetics





Figure 45: Presentation to SPEER, October 2012 (continued)


### BIPV Meets Homeowner Needs

DOW POWERHOUSE™




### BIPV Meets Homeowner Needs

CertainTeed Apollo



### BIPV Meets Homeowner Needs

DOW POWERHOUSE™



### BIPV Installation Minimizes Roof Penetrations

Roof integrity concerns are addressed



### BIPV: Installation Features

- Installs like a roof
- No live wires run above the roof
- No grounded components on the roof
- All conductors are touch-safe throughout the installation process
- Lightweight and easy to handle

### Key Codes



Figure 45: Presentation to SPEER, October 2012 (continued)

### Codes Addressing PV Systems

- International Residential Code (IRC)
  - One and Two-Family Dwellings
- International Building Code (IBC)
  - All Buildings Except One and Two-Family Dwellings
  - Multiple Single-Family not more than three stories
- International Fire Code (IFC)
  - Hazards of Fire in all new and existing buildings
  - Provide safety to fire fighters and emergency responders
- NFPA 70, National Electrical Code (NEC)
  - Article 690 Apply to Solar Photovoltaic (PV) Systems
- IAPMO Uniform Solar Energy Code (USEC)
  - Chapter 10 apply to Solar Photovoltaic Systems
  - Requirements are primarily extracted from NEC

### BIPV: International Residential Code (IRC)

- Recognizes BIPV as a Roof Covering
  - Photovoltaic Modules/Shingles: A Roof Covering composed of flat-plate photovoltaic modules fabricated into shingles.
- Section (R905.16) identifies requirements
  - Material Standard in Accordance with UL 1703
  - Installation in Accordance with Manufacturers Instructions
  - Wind Resistance in accordance with procedures and acceptance criteria in ASTM D 3161

### BIPV & BAPV: International Building Code (IBC)

- Recognizes Photovoltaic Modules/Shingles as a Roof Covering (Chapter 2)
- Photovoltaic Systems shall be labeled for fire (1505.8)
- Rooftop Photovoltaic Criteria is Defined (1509.7)
  - Wind Resistance in accordance with Chapter 16
  - Fire Classification must be the same as Roof Assembly
  - Installation in accordance with Manufacturers Instructions
  - Material Standard in accordance with UL 1703
- Solar photovoltaic Panels/Modules (1511)
  - Must comply with International Fire Code
  - Structure Fire Resistance – Frame and roof construction supporting the load shall comply with Table 601(Fire-Resistance Rating Requirements for Building Elements (Hours))

### BIPV Burning Brand Test - Class A



### BAPV Fire Tests Under Development



Source: UL, Effect of Back Mounted Photovoltaic Modules on the Fire Classification Rating of Roofing Assemblies

### BIPV: International Fire Code (IFC)

- Section 605.11 covers Solar Photovoltaic Power Systems
  - Marking is required on interior and exterior DC conduit, enclosures raceways, cable assemblies, junction boxes, combiner boxes and disconnects
  - Locations of DC conductors
  - Roof Access and Pathways spacing Requirements for various residential roof designs

Figure 45: Presentation to SPEER, October 2012 (continued)



Figure 45: Presentation to SPEER, October 2012 (continued)

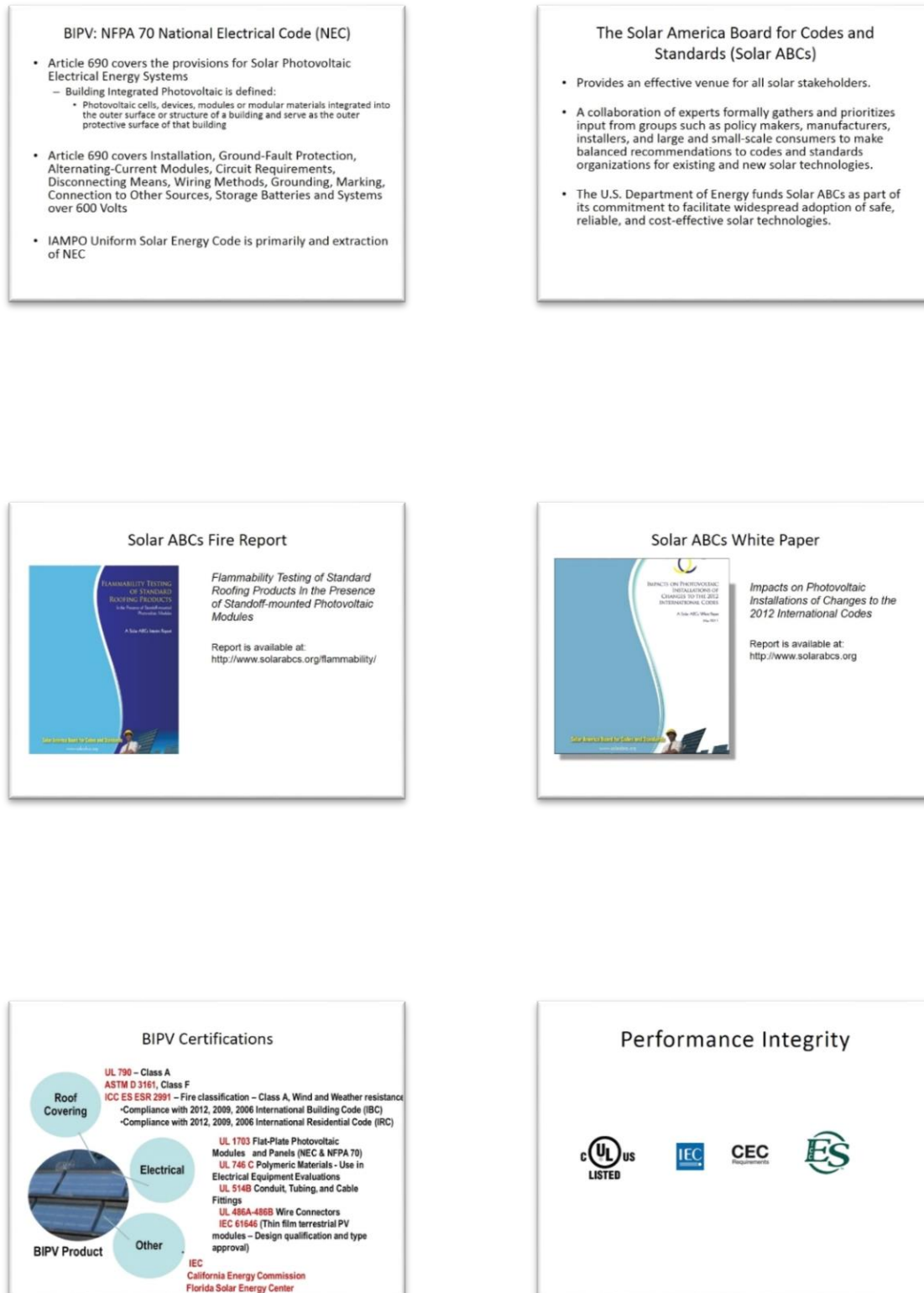


Figure 45: Presentation to SPEER, October 2012 (continued)





Figure 45: Presentation to SPEER, October 2012 (continued)

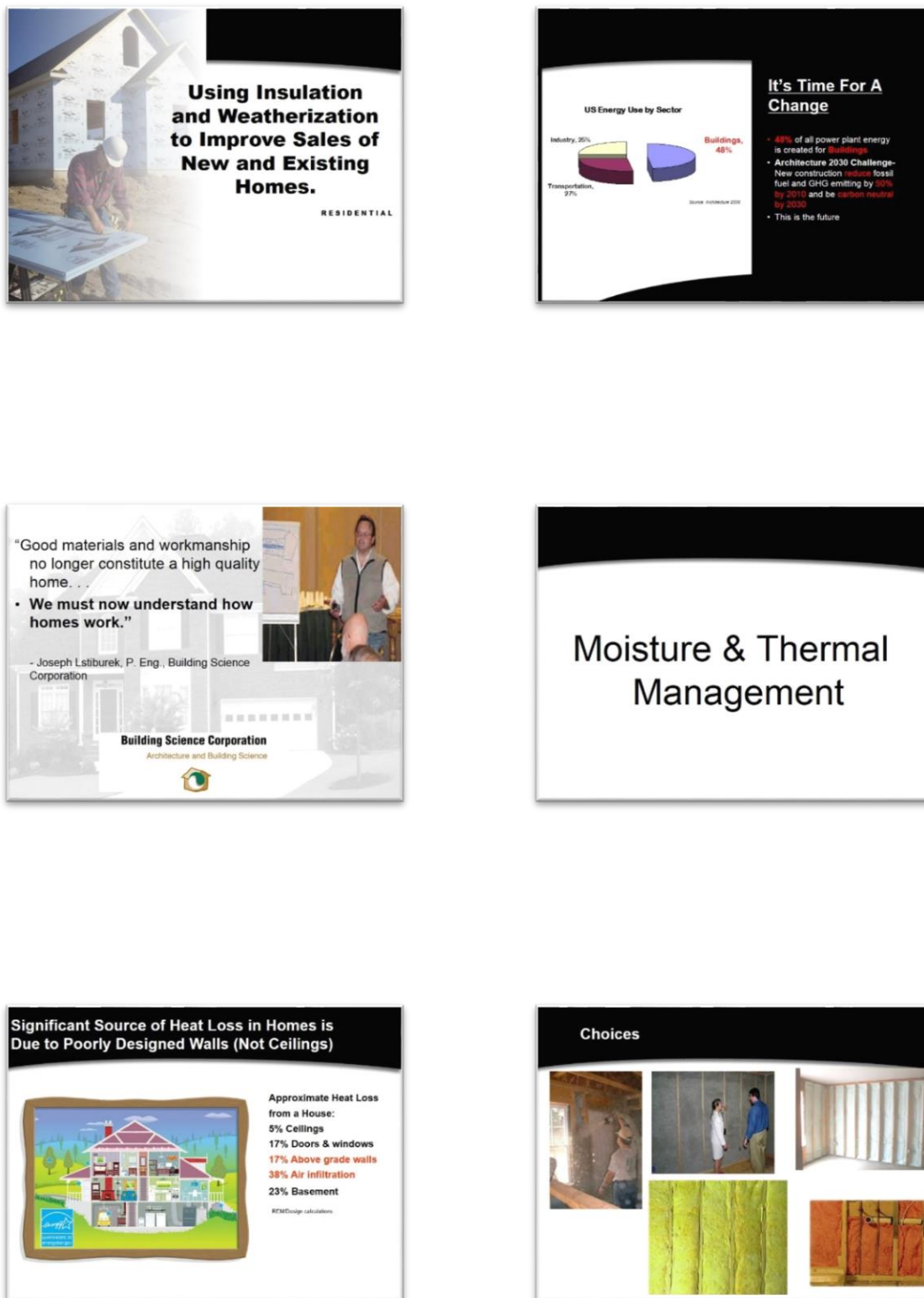


Figure 45: Presentation to SPEER, October 2012 (continued)

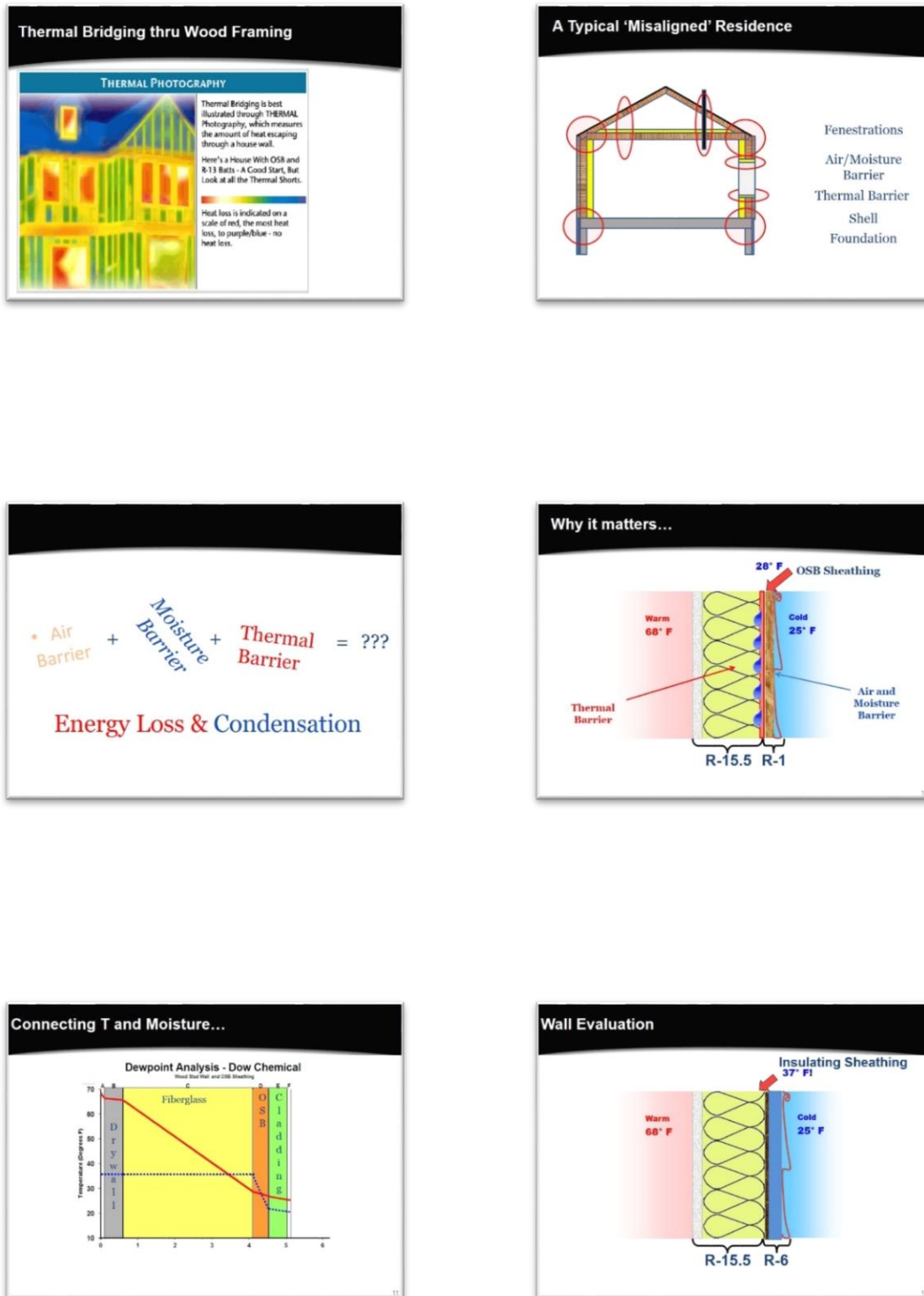
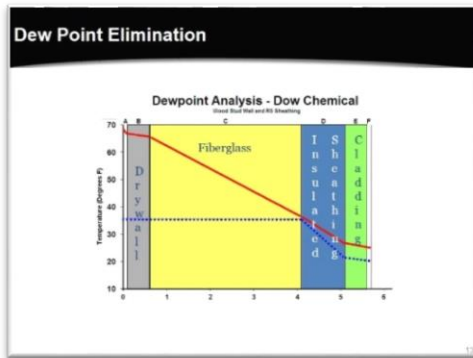


Figure 45: Presentation to SPEER, October 2012 (continued)



• Air Barrier + Moisture Barrier + Thermal Barrier = ???

Optimum **Thermal** and **Moisture Protection**

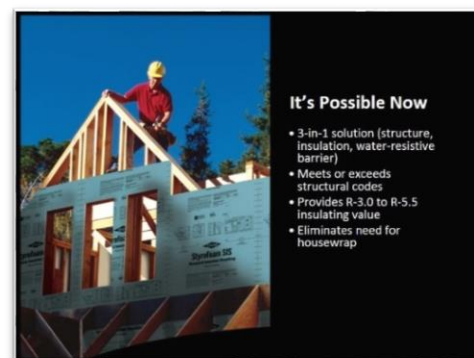
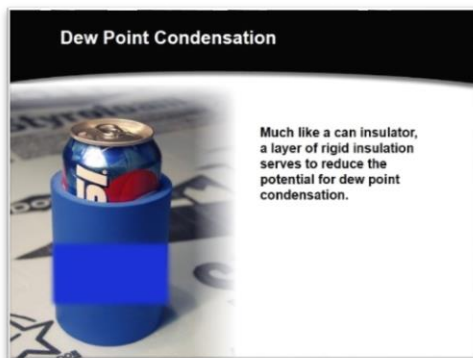


Figure 45: Presentation to SPEER, October 2012 (continued)

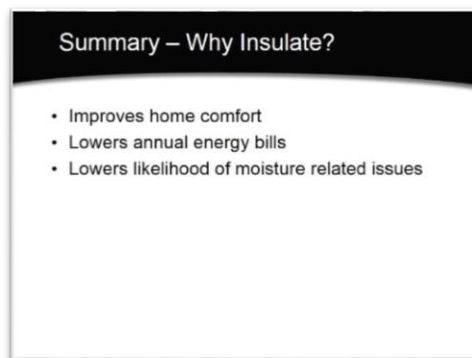
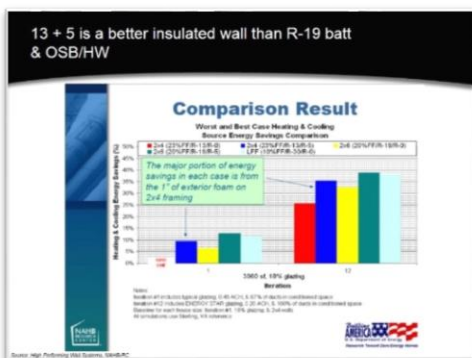
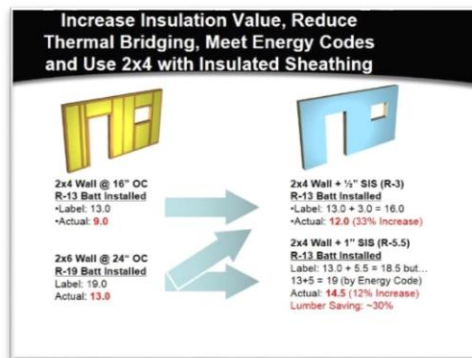
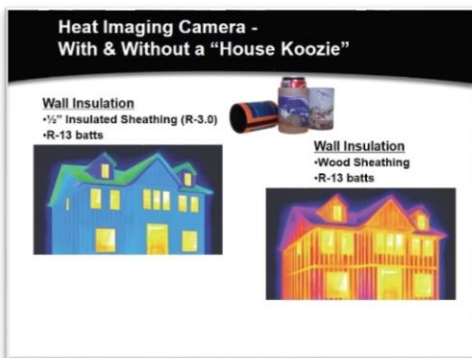


Figure 45: Presentation to SPEER, October 2012 (continued)



# Air Sealing

## Did you know...?



"The average 2500 square foot house has more than 1/4 mile of cracks and crevices which are open to wind and wind-driven rain."  
 \*\*\*Source: [www.airbarrier.org](http://www.airbarrier.org) (Water-Resistive Barriers)

## Current Situation

- Based on information from DOE, 80 MM detached homes in US need different degrees of insulation and air sealing
- Air leakage through holes, gaps and cracks contribute to 30%-50% energy used for most homes
- Air leakage is for both
  - Existing homes
  - New homes



## Inspect and Test for Air Leaks



## Scope of Field Study:

- 15 existing home built in 1926 to 2001 in MI, IN and OH
- 1 day of work using only air sealing products
- Accessible retrofit area
- Measurement of time/material/location
- Blower door test before and after each change
- REM/Rate calculations to estimate annual energy savings attributed to reduced air leakage

## Air Sealing Materials



**Two Component Foam**  
 Large coverage area  
 Thicker foam  
 Offers insulation (R-value)  
 Fast-cure  
 Self-contained kit



**Pro 20 oz**  
**Consumer 12 oz**  
**One Component Foam**  
 Small coverage area  
 Slightly slower cure  
 Smaller container  
 No mixing nozzle  
 Various expansion formulas

Figure 45: Presentation to SPEER, October 2012 (continued)

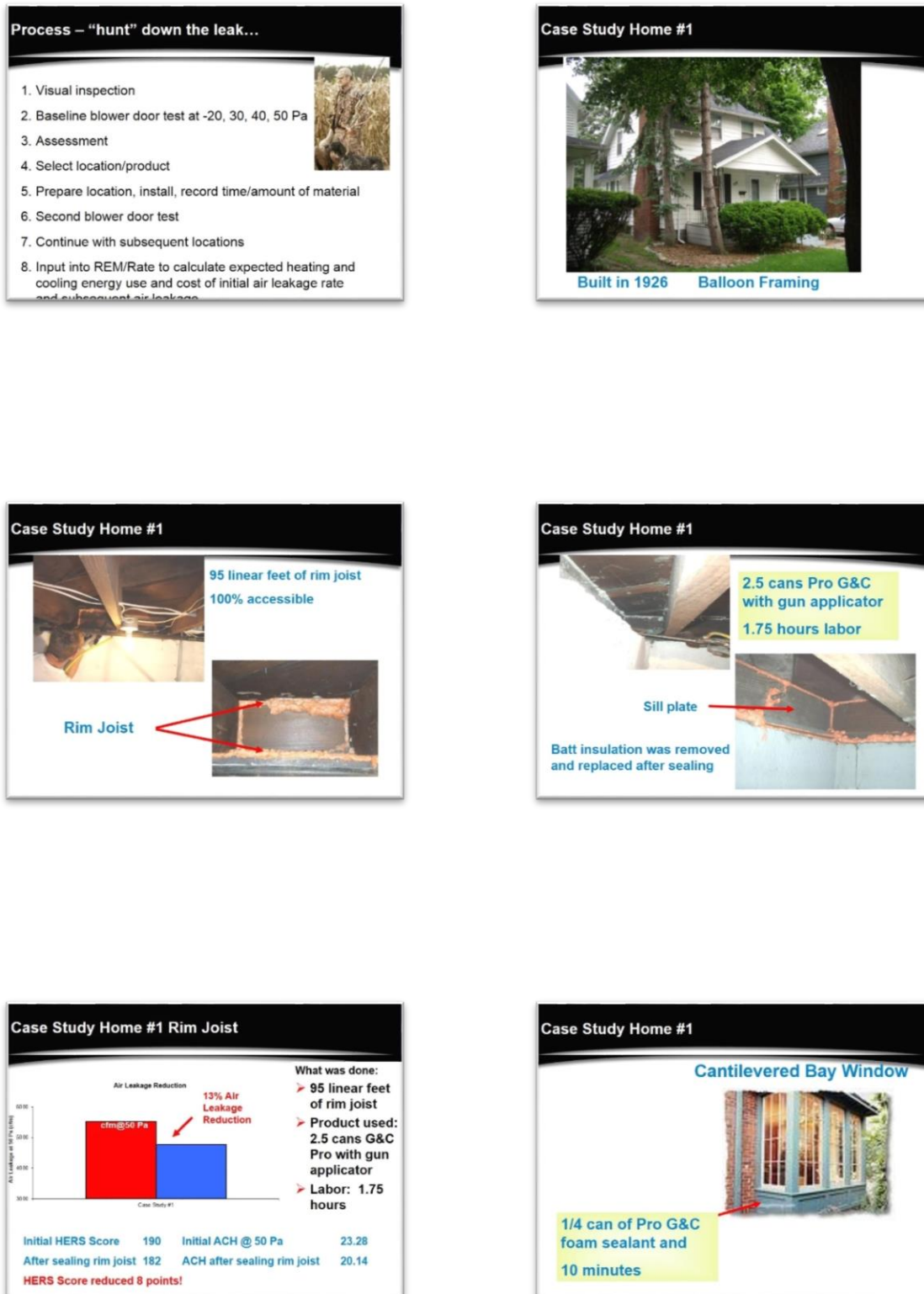


Figure 45: Presentation to SPEER, October 2012 (continued)

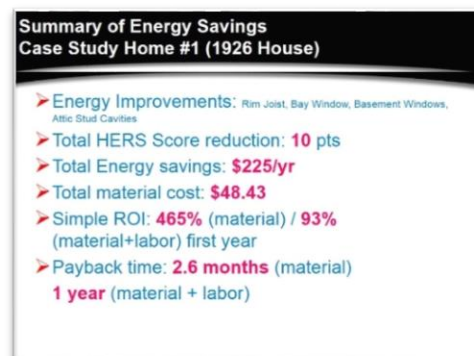
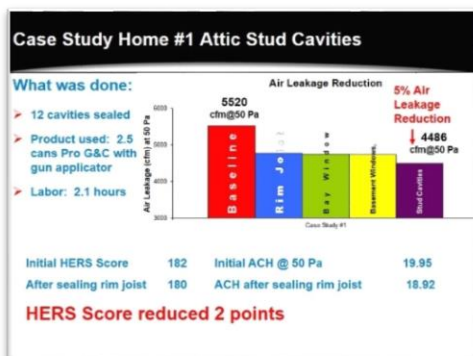
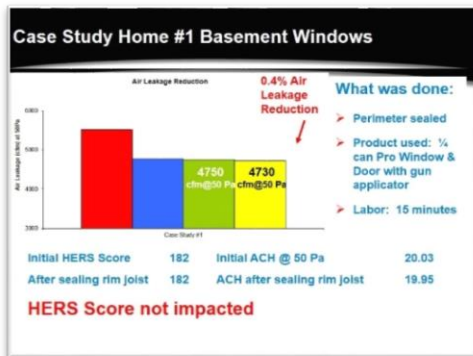
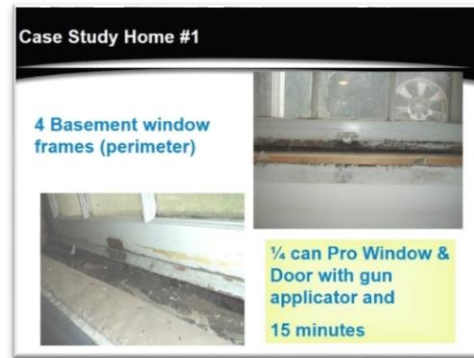
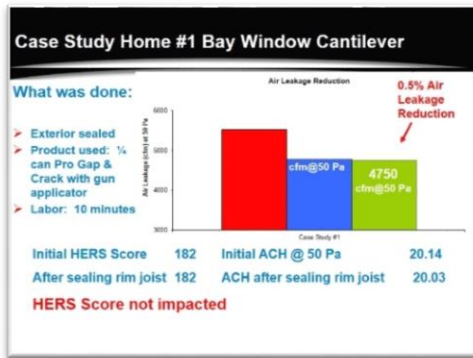


Figure 45: Presentation to SPEER, October 2012 (continued)

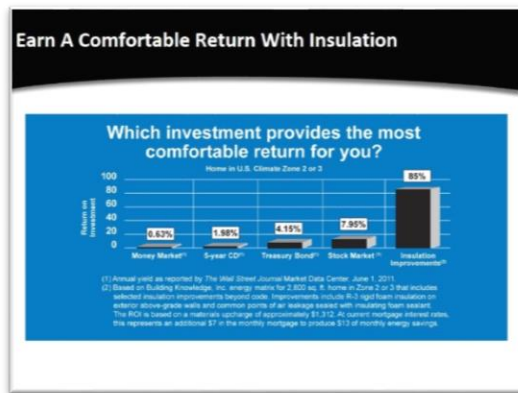


Figure 45: Presentation to SPEER, October 2012 (continued)



Figure 45: Presentation to SPEER, October 2012 (continued)



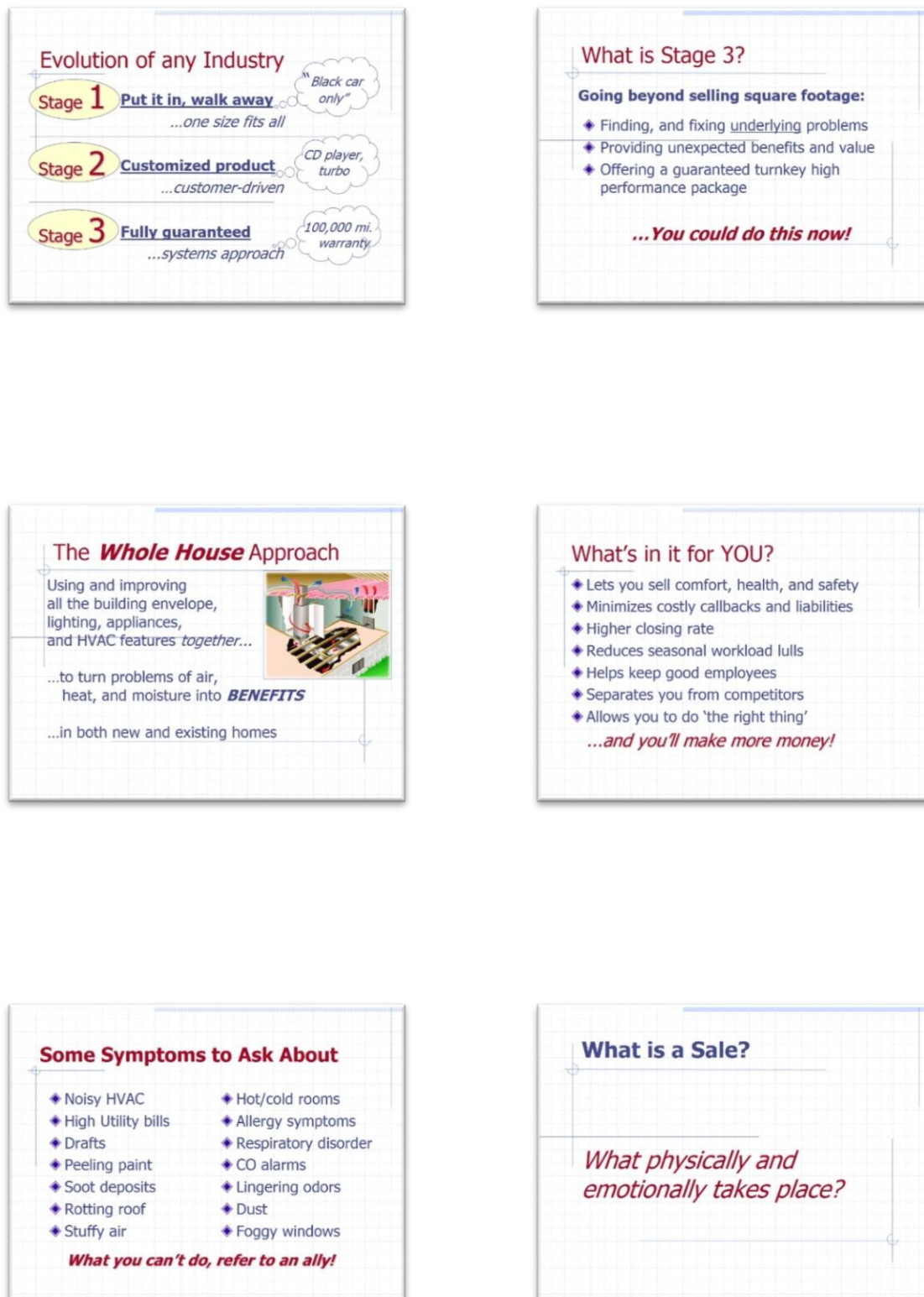


Figure 45: Presentation to SPEER, October 2012 (continued)



### Sale: **A transfer of feelings!**

Feelings Transferred:

- ◆ **Professionalism**
- ◆ **Value** (not "quality")
- ◆ **Enthusiasm**
- ◆ **Confidence\***

\*(knowledge and experience)

### What Don't You Sell?

- ◆ You don't sell energy efficiency!
- ◆ Efficiency is a logical attribute- no sizzle
- ◆ People make ALL decisions based on emotion – Yes, that includes you!
- ◆ Recent scientific research confirms that decisions are made in the emotional center of the brain and then in milliseconds, the brain asks the logical side to find a sound justification for the decision

### What *do* you sell?

**We sell *perceptions*...**

**justified by logic!**

Comfort	Appearance	Safety
Security	Convenience	Health
Appeal	Life Style	Status
Fashion	Success	Value
Leisure	Efficiency	Durability
Environment	Peace of Mind	...and more

### What Do You Sell?

- ◆ You Sell the Emotionally Loaded Values
- ◆ Then, when you have them wanting the comfort, health, low maintenance durability, social prestige, etc
- ◆ Then you give them a sound and undeniably logical justification to validate their emotional decision – Efficiency, ROI, based in good dollars and sense reasoning!

Brad Mann, owner of Comfort First Heating and Cooling in Lansing, Michigan, has embraced home-performance since 2004 and says in Home Energy Magazine:

- ◆ **"The Message Is Comfort"**
- ◆ "One of this industry's biggest problems is thinking that everyone really cares about saving the planet," said Mann. With very few exceptions, "the average homeowner couldn't care less . They care more about helping their asthma or being more comfortable."

Figure 45: Presentation to SPEER, October 2012 (continued)

Has a customer said to you...

- ◆ "We just felt better about you!"
- ◆ "We just felt you'd do a better job!"



How many times have you spent more than you had budgeted for a purchase, simply because you felt right about it?

Getting the customer to **feel right** is a valuable selling objective!

If the customer can see no difference between you and the competition...

**the purchase will be made on the basis of price!**

**Become memorable to your prospect!**

Involve the senses to bypass short-term memory and become embedded in long-term memory!



Investigation

**The Home Inspection and Diagnosis**

...The walk-through  
...Testing and tools  
...Inspection sequence



**The QC Commissioning or Walk-Through**

**What to look for...**

- ◆ Mold and moisture (also check RH)
- ◆ Indoor air pollution sources
- ◆ Evidence of dry rot
- ◆ Level of insulation and window quality
- ◆ Condition of roof (from attic)
- ◆ Duct installation and insulation
- ◆ Connection of plenum
- ◆ Power attic ventilation
- ◆ Noisy ducts

Figure 45: Presentation to SPEER, October 2012 (continued)





Figure 45: Presentation to SPEER, October 2012 (continued)

### We Must Link Features to Benefits In Our Customers Minds:

#### ◆ Pressure Tested to be More Comfortable:

- We test our homes under pressure using a scientifically designed fan to be sure that we've found and sealed the cold and hot drafts so that your home will be comfortable throughout the year.
- Our homes are tested to keep pollen and dust out and they have a mechanical ventilation system to breathe in fresh filtered air for your health every hour of every day.

### We Must Link Features to Benefits In Our Customers Minds:

- ◆ You can tag each of these feature/benefit statements with:
- ◆ "And that's not all, the sum total of all of these improvements is lasting value and a high performance house system that's energy efficient which keeps more of your family's hard earned dollars in your pocket every month."

### Cool Tools for Testing and Planting Flags!

#### **Blower Door**

...for duct leakage, infiltration, pressure boundary

#### **Digital Manometer**

...duct leaks, pressure mapping, back-drafting/flue draft

#### **Moisture Meter**

...to locate leaks, identify hidden moisture/mold (not dry air sources)

### MORE Cool Tools...

#### **CO Tester**

...for appliance safety, flue backdraft, CO exposure (not smoke alarm testing)

#### **Flow Hood**

...air balancing, identifying causes of airflow-related discomfort

#### **Smoke Puffer**

...customers love it!

#### **Duct Pressurization Tester (blaster)**

...to quantify duct leakage

### Getting the *Order...*

**Eye contact is absolutely crucial!**

If you're not going to use eye contact, you might as well FedEx your presentation!



### Tell your prospect...

- ◆ *what their special needs are*
- ◆ *what makes you different from the competition*
- ◆ *what unique benefit they derive from your service*

Figure 45: Presentation to SPEER, October 2012 (continued)





Figure 45: Presentation to SPEER, October 2012 (continued)




Figure 45: Presentation to SPEER, October 2012 (continued)

Presentation to SPEER, December 2012

### BOC Tech Talk

**Toolkit for Building Diagnostics**



BOC Tech Talk is a collaboration of the Building Operator Certification and NEEA's BetterBricks

Material for this presentation provided by PG&E Pacific Energy Center

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### Objectives


**Identify tools that help to identify low cost energy savings opportunities**

- Introduction to data loggers
- Tools for lighting
- Discuss additional helpful tools
- Suggest a "starter kit" of tools and loggers

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### What are Dataloggers?


- What they do
  - Measure
  - Record
- What they include
  - Receive signal from sensor or transducer
  - Data sampling rate
  - Data storage rate (interval or event)
  - Memory for data storage
  - Internal clock
  - Computer data connection
  - Programming and data retrieval software
  - Power supply
  - Microprocessor
  - Analog-to-digital converter



© 2012

### Types of Loggers

- **Status loggers** (aka runtime or time-of-use)
  - Captures transition between on and off
  - Records a time stamp and present status
- **Interval loggers**
  - Data represents either a snapshot or average value at end of a desired time interval
  - Sample rate and recording interval may be different



© 2012

### Applications for Status Loggers

- Verify scheduled controls are working
- Verify occupancy sensors control lighting properly
- Discover if equipment is over cycling
- Can use motor run-time + nameplate data to estimate annual energy usage or energy savings from an upgrade

© 2012

### Applications for Interval Loggers

- Make sure space is kept within programmed setpoints and setbacks
- Make sure space is comfortable 68°F to 80°F
- Measure outside air (& system response to change in OSA)
- Verify temperature-related control strategies
  - Night-time setbacks
  - Lock-outs
  - Night ventilation



© 2012 Air-side economizers

Figure 46: Presentation to SPEER, December 2012

### Equipment Scheduling

#### Runtime Monitoring

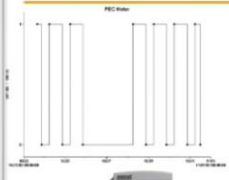
- Measures the hours of operation
- Constant HVAC loads
  - Pumps
  - Fans
  - Boilers
  - Single-stage compressors
- Non-dimmable lighting
- $kWh = kW \times \text{Runtime}$


© 2012

### Equipment Scheduling

#### Runtime Data



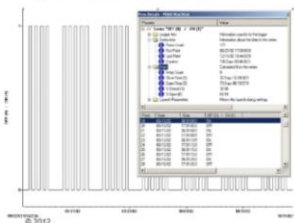



- Records only ON and OFF conditions and a timestamp
- Very effective use of memory
- Not acceptable for variable power loads when measuring energy use
- Sensor types
  - Light level
  - Electro-magnetic field
  - Vibration



© 2012

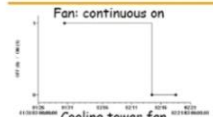
### Equipment Scheduling

#### Motor runtime data

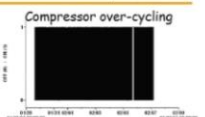





© 2012

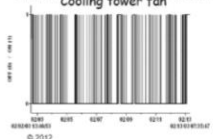
### Run-Time Data from Status Loggers



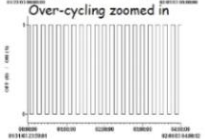
Fan: continuous on



Compressor over-cycling



Cooling tower fan

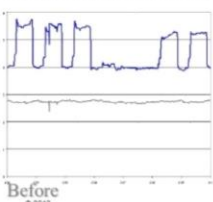


Over-cycling zoomed in

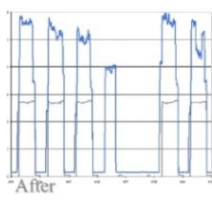
© 2012

### Interval Loggers and Scheduling

Use interval data (power or current)  
To determine Air Handler Run-time



Before

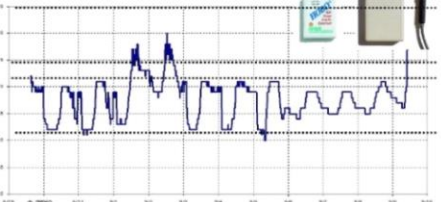



After

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### Interval Loggers and Scheduling

Use space temperature to verify HVAC equipment schedules, setpoints and setbacks

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Figure 46: Presentation to SPEER, December 2012 (continued)

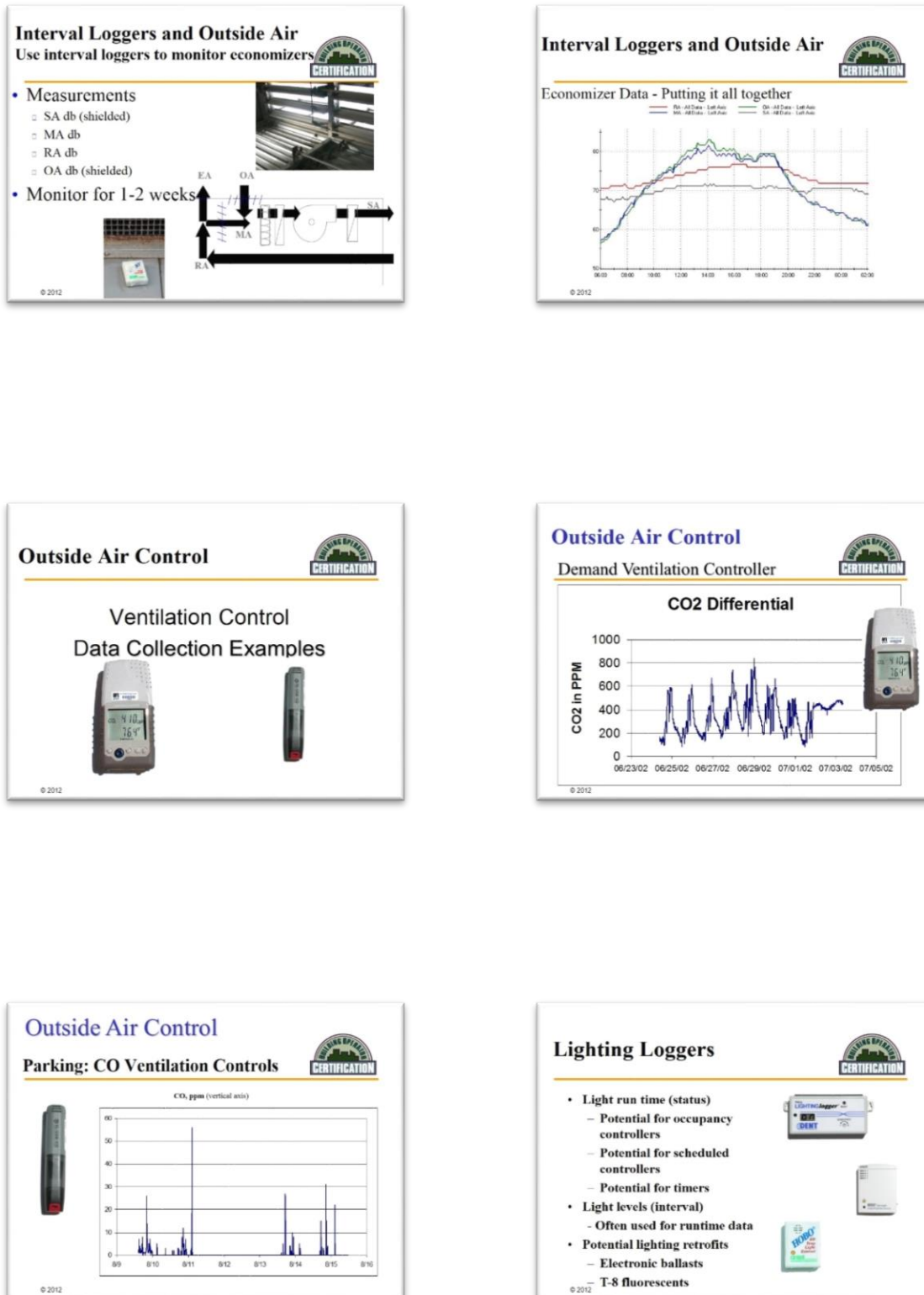


Figure 46: Presentation to SPEER, December 2012 (continued)



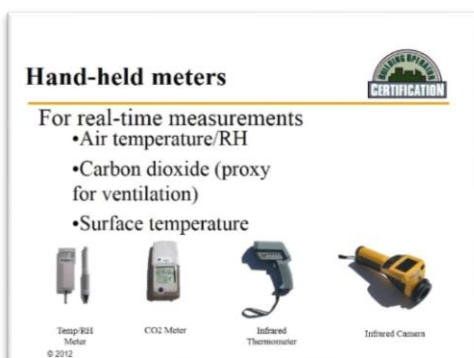
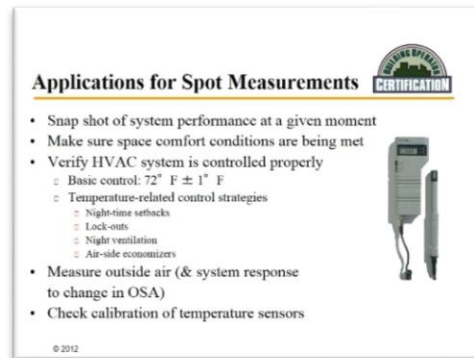
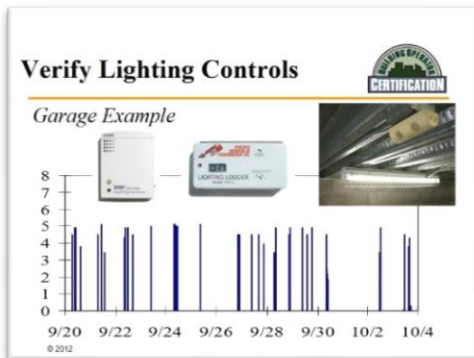
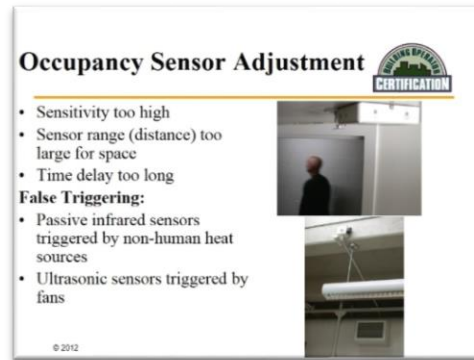
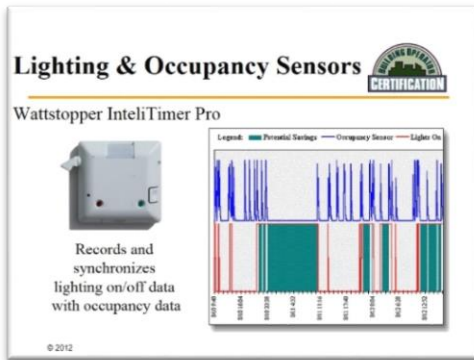


Figure 46: Presentation to SPEER, December 2012 (continued)

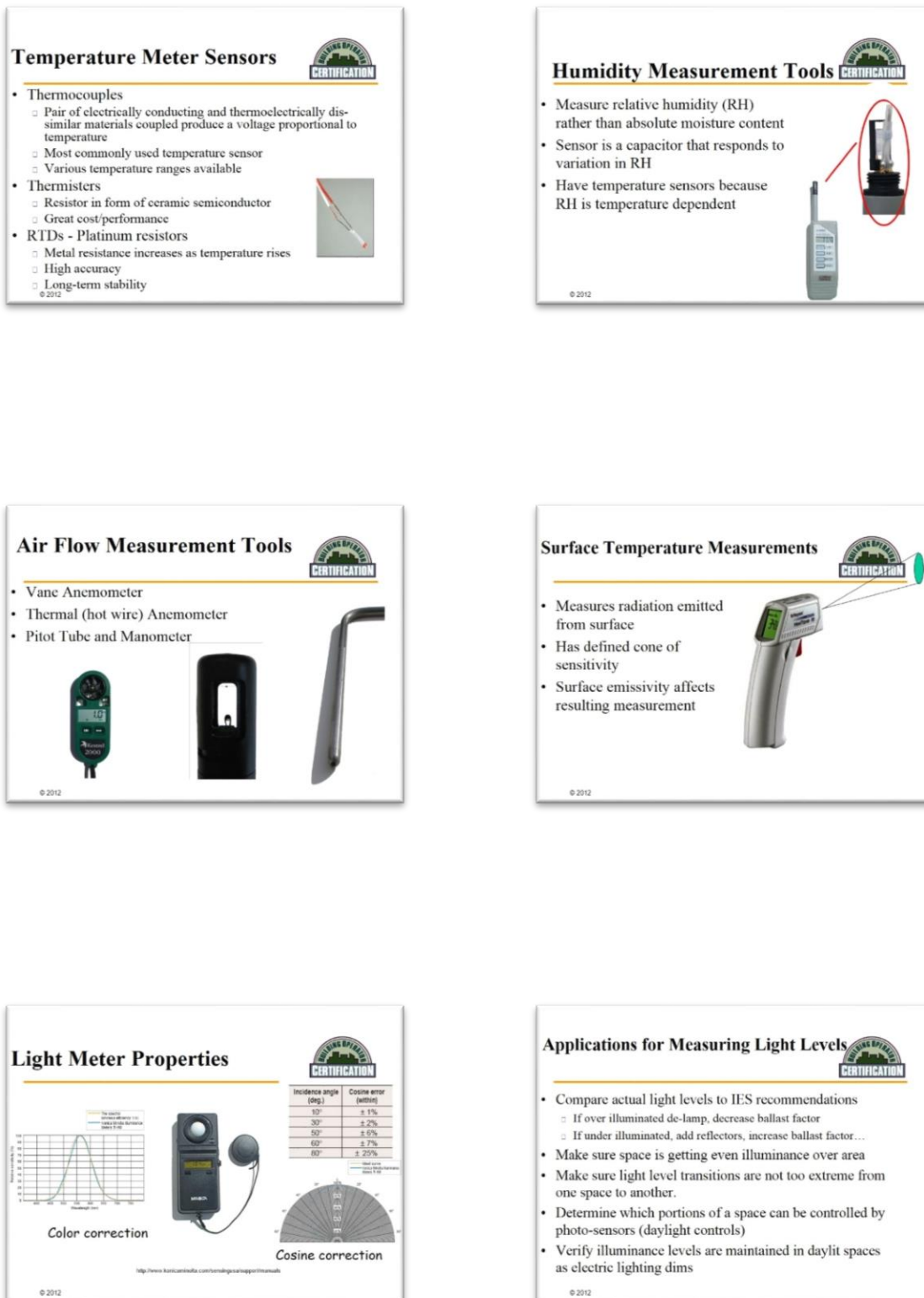



Figure 46: Presentation to SPEER, December 2012 (continued)

### Recommended Illuminance Levels




1. Illuminance Categories and Maintenance Values for Generic Types of Activities in Interiors


Type of Activity	Reference Category	Range of Illuminance Lux	Footcandles	Reference Work Plane
Public spaces with dark surroundings	A	20-30-50	2-3-6	
Simple orientation for short temporary tasks	B	50-75-100	5-7.5-10	General lighting throughout spaces
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	Illuminance on task
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	
Performance of very prolonged and exacting visual task	H	5000-7500-10000	500-750-1000	Illuminance on task, obtained by a combination of general and local (task) lighting
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

From: Lighting Handbook, 9th Edition, 1993 p. 465 © Illuminating Engineering Society of North America 2000A metric equivalent copyright © 2012

### Recommended tool kit




- Temperature/RH meter (\$250 - \$500)
- Non-contact infrared temperature meter (\$75 - \$400)
- CO2 meter (\$450 and up)




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### Recommended tool kit




**For lighting opportunities:**

- Illuminance meter (\$150 - \$400)
- Lighting ballast discriminator (\$50 - \$75)




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### Recommended tool kit - loggers




- **Temperature/RH loggers** (\$75 - \$125 ea) for economizer assessment, air handler sensors, thermostat checks, etc. Quantity 6 - 7 for economizer study and other applications
- **Light and motor on/off loggers** (\$75 - \$125 ea) for finding de-lamping opportunities, scheduling and motion sensor verification. Quantity 3 and up
- **External input configurable loggers** (\$80 - \$450) accept inputs for CO2 logging, current, contact surface temperatures, etc. Quantity 2, facility-dependent
- **CO loggers** (\$100 ea, qty 2+) if your facility has a parking garage




© 2012


### Resources



Building Operator Certification  
[www.TheBOC.info](http://www.TheBOC.info)



NEEA's BetterBricks  
[www.BetterBricks.com](http://www.BetterBricks.com)



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Figure 46: Presentation to SPEER, December 2012 (continued)

## BOC Tech Talk

### Lighting Technology Showcase



BOC Tech Talk is a collaboration of the Building Operator Certification and NEEA's BetterBricks

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## Presentation Approach

Practical information on efficient products

- Design and technology
- Efficiency and performance
- Cost and availability
- Application
- How it compares with others

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## Advancement in Lamp Technologies driving the industry

Low Wattage T8's →

LED/SSL →

Induction →

Plasma →



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## Low Wattage T8's

- over 40,000 hour life on Instant Start Ballast (12hr)
- Over 45,000 hour life on Program Start Ballast (12hr)
- 25W, 28W, 32W
- Cost ~ \$3.50
- Lumen Depreciation ~
- **94 lumens per watt**
- **Low mercury dosing (eco)**

Linear fluorescent: source Platt  
 Electric 25W/28W/32W: \$3.25  
 High performance T8 (3100 lumens): \$2.25  
 Long life: \$1.75-2.25  
 T8HO: \$4.95  
 Electronic ballast: \$12-15

© 2012

## Low wattage T8 Ideal for Retrofit

High LPW makes it a good competitor  
 Existing luminaires  
 No new design  
 Retrofit 2.0



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## LED/SSL



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Figure 46: Presentation to SPEER, December 2012 (continued)

### LED Design and Technology

LEDs produce illumination by the movement of electrons in a semiconductor material.

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### LED Design and Technology

LEDs are very directional

© 2012

### LED Design and Technology

LEDs do get hot, but in a different way  
LEDs last a very long time if heat is managed  
but they eventually depreciate in light output

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### LED Design and Technology

The convergence of lamp and luminaire

© 2012

### LED efficiency and performance

Anywhere from 30 to 55+ LPW (some over 100)  
– but it's directional! LPW is not a fair measure  
Life – depending on heat, it's upward of 50,000 hrs or more  
Various sizes by manufacturer (again – is it a lamp or a luminaire?)

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### Cost and availability (Retrofit)

Downlight (\$50 - \$80)  
A-lamp (\$29 - \$39)  
PAR - lamp (\$55+)  
MR - lamp (\$25)

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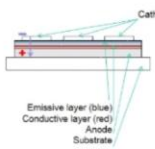
Figure 46: Presentation to SPEER, December 2012 (continued)





Figure 46: Presentation to SPEER, December 2012 (continued)

### OLED Technology



Electrical current flows from the cathode to the anode through the organic layers. Electrons find holes between the emissive and conductive layers. When it finds this hole, the electron fills the hole and gives up energy in the form of a photon – emitting light!

- Paper thin
- Efficacy ~25 lpw
- Life ranges from 5,000 hours – 30,000 hours
- Very Expensive

© 2012

### Application

- Signage
- Ceiling/floor/building panels
- Task lighting
- Restaurants designs
- Decorative "accent" lighting



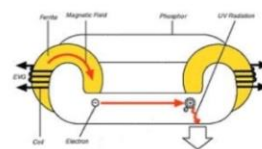
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### Induction Lighting



© 2012

### Induction technology



The induction coil produces a very strong magnetic field which travels through the glass and excites the mercury atoms in the interior which are provided by a pellet of amalgam (a solid form of mercury). The mercury atoms emit UV light and, just as in a fluorescent tube, the UV light is up-converted to visible light by the phosphor coating on the inside of the tube.

© 2012

### Induction lighting

- Up to 100,000 hours depending on lamp model
- Electrodeless
- Up to 90 LPW
- High CRI and multiple CCT
- Instant on and available in different wattages
- Some are dimmable
- \$450 to \$550 for a 200W assembly

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### Applications




© 2012

Figure 46: Presentation to SPEER, December 2012 (continued)


### Plasma Lighting



CERAVISION



LUXIM



TOPANGA



© 2012

### Plasma Technology


- Plasma – a radio frequency signal is generated around the bulb. Energy vaporizes the contents of the bulb to a plasma state, the plasma generates light.
  - Consists of Emitter, RF driver & Power supply
- 115-140 LPW (lamp only) 71-90 LPW (system)
- 30,000 to 50,000 hours for lamp life
- Claims 100W to 5000W lamp (up to 450,000 lumens per system) with tunable CCT (2000 to 10000) & 70-95 CRI
- For cost contact manufacturers:
  - Ceravision, Luxim, Topanga

© 2012

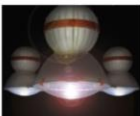
### Applications

Roadway/area lighting



Theatrical



High ceiling interior spaces

© 2012

### Conclusion

All about the application

LEDs good for downlights, decorative and some exteriors, we will continue to see more.

High performance T8s are king!

Induction lamp is more viable than ever!

OLED may be the interior lighting of the future but not yet.


Plasma is up and coming (wait and see)

© 2012

### Resources

Building Operator Certification  
[www.TheBOC.info](http://www.TheBOC.info)

NEEA's BetterBricks  
[www.BetterBricks.com](http://www.BetterBricks.com)

 **BETTERBRICKS** Powerful Energy Ideas. Delivered by NEEA.

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Figure 46: Presentation to SPEER, December 2012 (continued)


## BOC Tech Talk

### Walking the Building for Common Opportunities

BOC Tech Talks are a collaboration of Building Operator Certification and NEEA's BetterBricks

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## Is Your Building Eating Too Much Energy?

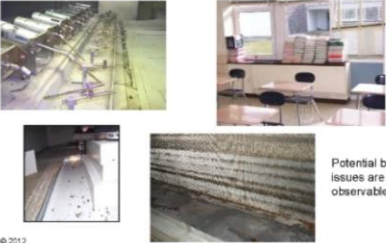


How much is too much?

Most buildings can cut total energy use by 5-30% while fully maintaining or improving both comfort and function.

© 2012

## Walking Your Building



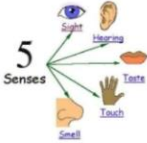
Potential building issues are observable

© 2012

## O&M Practices

### Using your senses:

- What do you see?
- Can you hear that?
- What's that smell?
- This is hotter than usual! Why?
- Taste? Maybe not.



What building issues can be detected using your 5 senses?

© 2012

## Start with a Scoping Action Plan


It is tempting to jump into investigation—but, up-front work is needed to:

- Reduce investigation time
- Avoid extra follow-ups that may not be budgeted or disrupt normal operation

© 2012

## What is Scoping?


- The outcome of a building energy scoping is a proposed scope of work for a building energy tune-up
- A building energy tune-up is a periodic process intended to fix problems and to improve operation



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Figure 46: Presentation to SPEER, December 2012 (continued)

### Why Do Scoping?



- Plan ahead for a systematic tune-up process
- Know where the best investment of time is for detailed analysis
- Determine the appropriate level of effort and cost
- It's a good tool to gather and present information to managers


© 2012

### Developing a Scoping Action Plan

<b>1. Gather</b> <ul style="list-style-type: none"> <li>Basic building information</li> <li>Energy bills</li> <li>Daily utility load data</li> </ul>	<b>3. Interview</b> <ul style="list-style-type: none"> <li>What documents are available</li> <li>Known problems</li> <li>Staffing</li> </ul>
<b>2. Analyze</b> <ul style="list-style-type: none"> <li>Energy Use Index (EUI)</li> <li>Benchmark result</li> <li>Trends, load factors</li> <li>Daily load data findings</li> </ul>	<b>4. Plan</b> <ul style="list-style-type: none"> <li>Building walkthrough plan</li> </ul>

© 2012

### Gather Information



Utility data: Make sure to include all meters and fuels!

- Electric
- Gas
- Steam
- Chilled water
- Oil
- On-site generation (used on site)
- Daily load data

© 2012

### Gather Information

**Basic Information for Benchmarking**

**General Office 1:**

**Required:**

100,000 Gross floor area (SF)

56.5 Weekly operating hours

400 # of workers on main shift

455 # of personal computers

100 Percent of floor area that is air conditioned

100 Percent of floor area that is heated

No Parking

© 2012

### Analyze

Calculate Energy Use Index (EUI)

- Total Energy Use/sqft conditioned space/year
- Commonly expressed as kBtu/sqft/yr

Or

Use Portfolio Manager to get the EUI and a benchmarking score:

- ACME Office Energy Star Score = 46
- EUI = 96 kBtu/sqft/year

© 2012

### Interview

Interview other staff to:


- Evaluate overall O&M practices and capabilities
- Identify any known issues with equipment
- Identify existing comfort and maintenance problems

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Figure 46: Presentation to SPEER, December 2012 (continued)



### Walkthrough Plan



1. Monthly Billing Analysis
2. Interval Data Analysis
3. System Summary
4. Document Checks
5. Equipment and System Checks

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### Example Walkthrough Plan

#### 4. Document Checks

Are the following items available? *(List only if correct and current)*

ITEM	YES	NO	LOCATION
Division 15 and 16 Specifications	X		Facility Office
Mechanical Drawings	X		Facility Office
Control Sequence Description		X	In programming
Control Drawings	X		Facility Office
FMCS Points List	X		Facility Office
FMCS Program Print Out		X	Can print out
Electrical Drawings	X		Facility Office
Equipment Repair History	X		Facility Office
Test And Balance Report	X		Facility Office
Manufacturer Startup Documentation	X		Facility Office
O&M Manuals (For Controls and Major Equipment)	X		Facility Office

© 2012

### Example Walkthrough Plan

#### 5. Equipment and System Checks

- Discharge air temperature control
  - Look at and record reset schedule and/or strategy
  - Record discharge, mixed air, outside air and return air temperatures if possible
  - Examine sequence of operations for box control
- Chiller operations
  - Chilled water reset control and setpoints
  - Chiller run hours
- Boiler operations
  - Heating water temperature control
  - Boiler run hours
- Unusual cooling loads
  - Look for large internal zones
  - Check for how internal loads are served by HVAC
- Outside air use
  - Check economizer control setpoints (high temp lockout, min outside air position, low temp lockout and control type)
  - Check to ensure dampers are operable
  - Check CO<sub>2</sub> levels
- Unusual occupancy
  - Any 24-hour occupied or HVAC areas
  - Check schedules for excessive after hours use

© 2012

### Tools for a Walkthrough

The basics:

- Rags to clean nameplates
- IR temperature sensor
- CO<sub>2</sub> sensor
- Flashlight
- Digital camera
- Safety gear

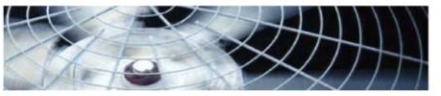
Might be nice:

- Multimeter
- Insertion thermometer
- Small toolkit (screwdriver, pliers, etc.)
- Stethoscope
- Tape measure
- Cell phone or walkie-talkies

© 2012

### Top Four Opportunity Areas for a Building Tune-Up


- Equipment scheduling
- Sensor error
- Simultaneous heating and cooling
- Outside air usage



© 2012

### Equipment Scheduling

- The easiest way to save equipment energy is to turn it off!
- Also, longer operating hours:
  - Results in shorter equipment life
  - Increases the frequency of parts replacement
  - Causes the need for more frequent cleaning (chiller bundles, boiler tubes, fan coils, etc.)
- A good first step is to walk through the building when it is unoccupied.



© 2012

Figure 46: Presentation to SPEER, December 2012 (continued)



Figure 46: Presentation to SPEER, December 2012 (continued)

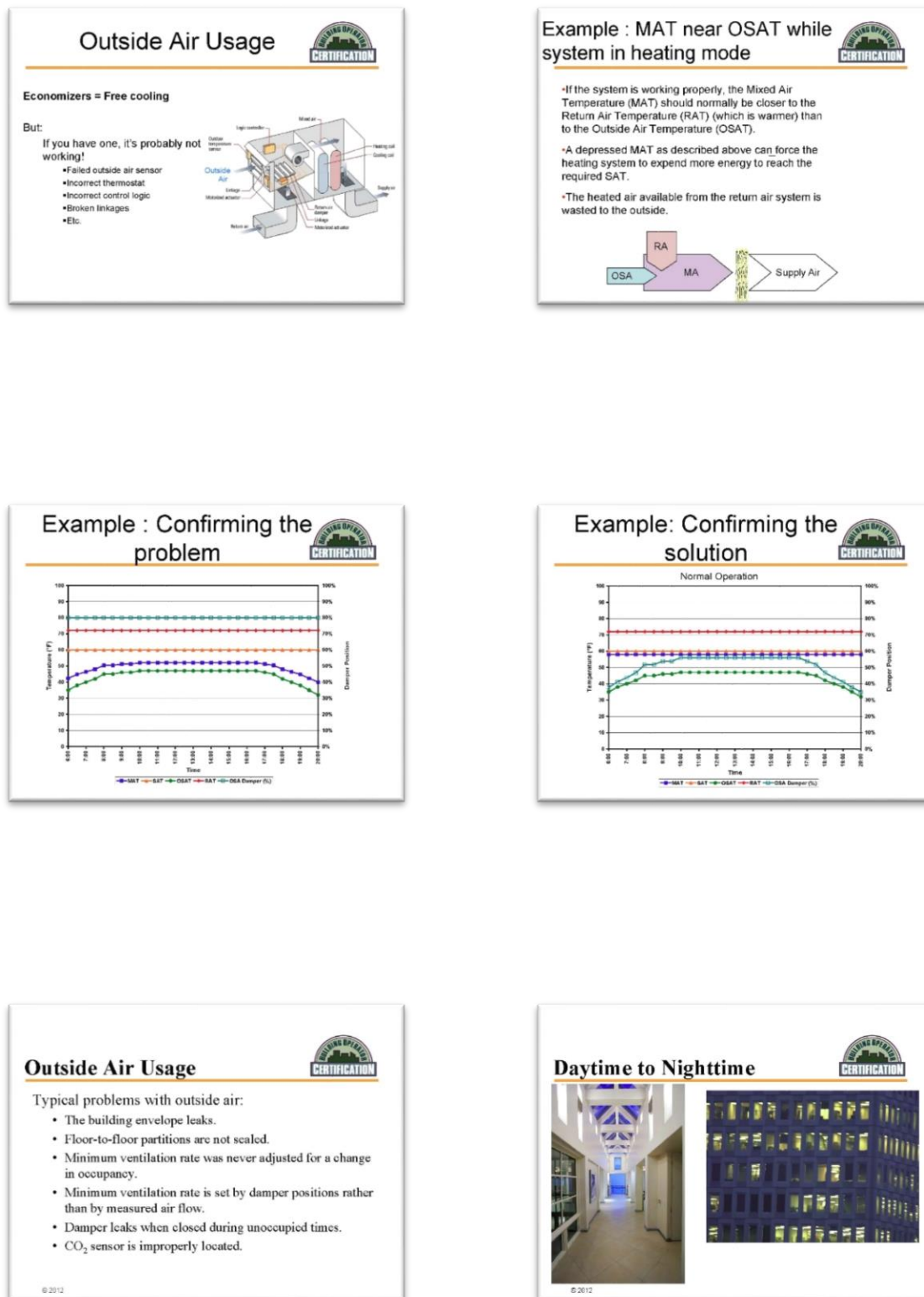



Figure 46: Presentation to SPEER, December 2012 (continued)

### A Night Walkthrough

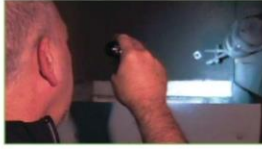
When your building is unoccupied, how do you know what is happening?

Periodic night walks are the key to finding out.



© 2012

### Night Walks



Most building engineers focus on daytime operation.

Walking the building at night can provide good insight into operational issues

Courtesy of BetterBricks

In most buildings, 5,000 to 6,200 hours per year, they are unoccupied


© 2012

### Night Walkers' Toolbox

- Flashlight with good batteries
- Camera for documenting findings
- Temperature sensor and/or portable data logger with temp and humidity sensors
- Small toolkit for accessing filters, mixing boxes, etc.
- Hand-held radios or cell phones
- Warm clothes in case extended time on the roof
- If possible, an infrared camera

© 2012

### What can you find?



Look Listen Feel! Smell

- Equipment running that shouldn't be
- Lights on that don't need to be
- Air movement caused by failed dampers
- Plug loads like coffee pots, space heaters that are still on
- Dripping water from a plumbing leak
- Mold smells from a water leak
- And much more...

Courtesy of BetterBricks

© 2012


### The Night Walkers' Roadmap

The walk should encompass the entire building, but focus On the following areas

- Mechanical rooms
- Areas near the top of the building, including the top of stairwells and the roof
- The main lobby and elevator lobbies
- A typical tenant space in each HVAC zone

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### Night Walk Video Series



Check out the short video series on night walks at


[www.betterbricks.com](http://www.betterbricks.com)

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Figure 46: Presentation to SPEER, December 2012 (continued)

### BOC Tech Talk

#### Economizers – Free Cooling



BOC Tech Talk is a collaboration of the Building Operator Certification and NEEA's BetterBricks

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### Small Packaged HVAC Equipment



- ❑ Packaged Rooftop Units (RTU)
  - ❑ Gas Packs
  - ❑ Heat Pumps
  - ❑ All Electric Air Conditioning Units
- ❑ Sized in tons of cooling capacity btuh of heating capacity.
- ❑ They condition a large fraction of all commercial building spaces.
- ❑ Mostly constant volume - also includes VAV and VVT



© 2012

### Market Characterization

- ❑ 34% of commercial buildings have packaged HVAC units
- ❑ 150,000 – 175,000 units in the field (522M sf of space)
- ❑ New sales of approx. 7,000-9,000 units
- ❑ Approximately 800 contractors in light commercial HVAC

Data for Pacific Northwest region  
Published in Light Commercial HVAC Market Assessment - Report No. 05-501-028  
Northwest Energy Efficiency Alliance, 2005


© 2012

### How are RTUs rated?

- ❑ Seasonal Energy Efficiency Ratio (SEER)
- ❑ The higher the SEER rating of an RTU, the more energy efficient it is. The SEER rating is the Btu of cooling output during a typical cooling-season divided by the total electric energy input in watt-hours (W·h) during the same period.

$$SEER = BTU \div W \cdot h$$

- ❑ Minimum federal requirement = 13 SEER



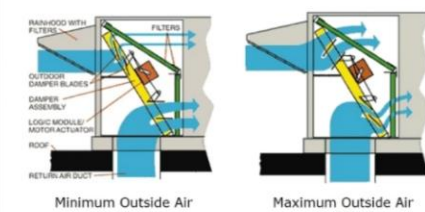
### Packaged Rooftop Equipment



Source: York International Corp.

© 2012

### Packaged Unit Economizer



© 2012

Figure 46: Presentation to SPEER, December 2012 (continued)



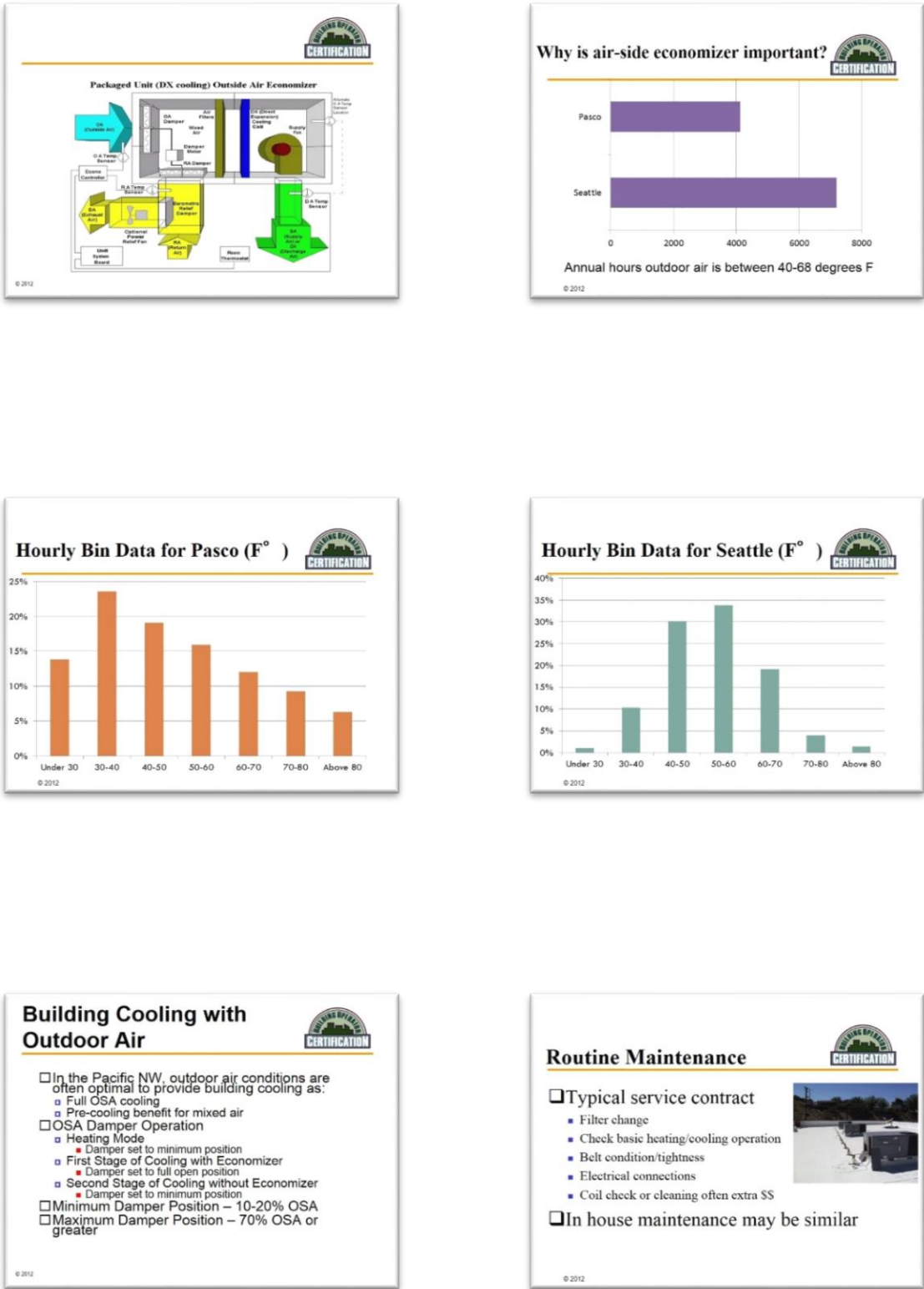


Figure 46: Presentation to SPEER, December 2012 (continued)

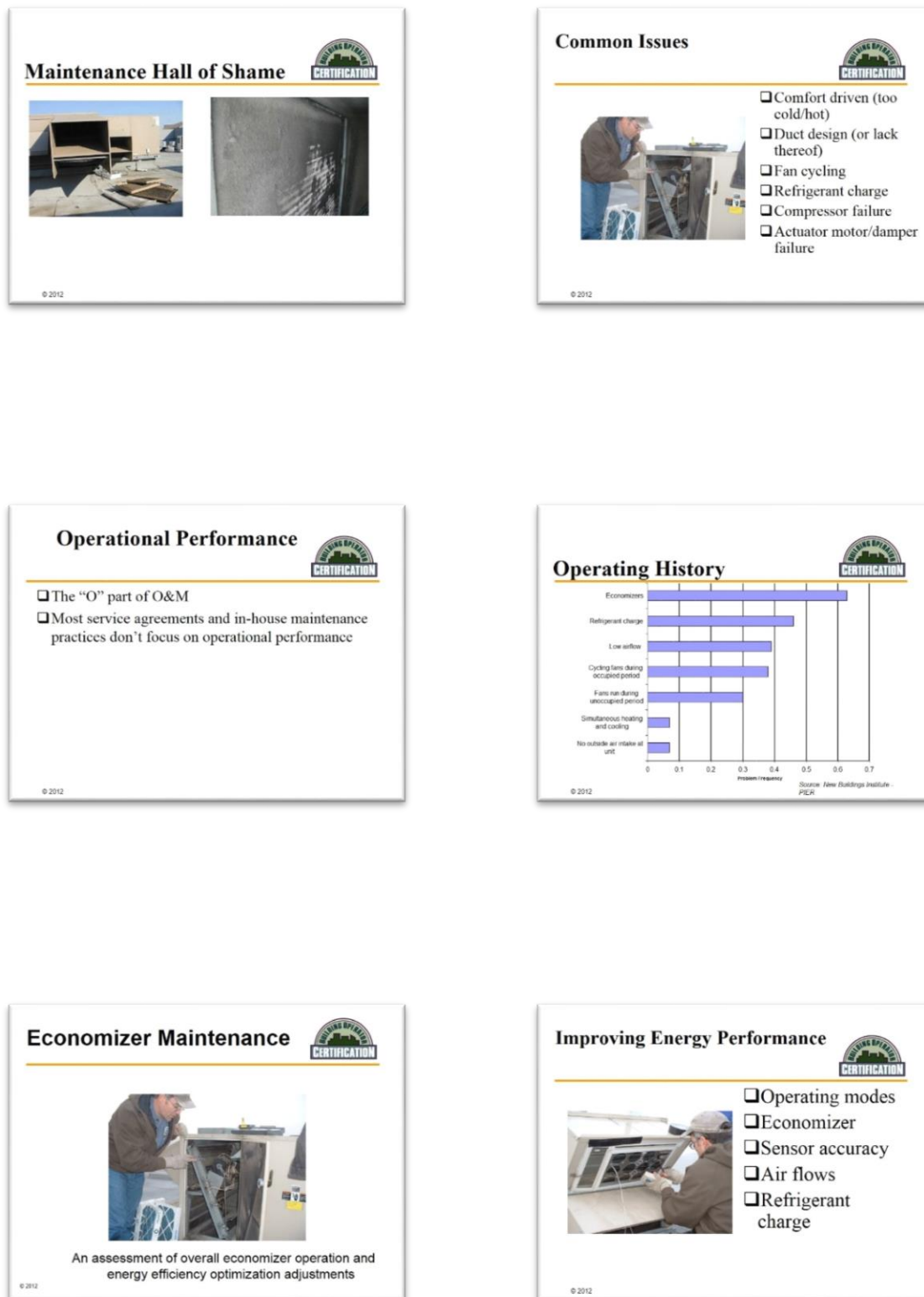


Figure 46: Presentation to SPEER, December 2012 (continued)

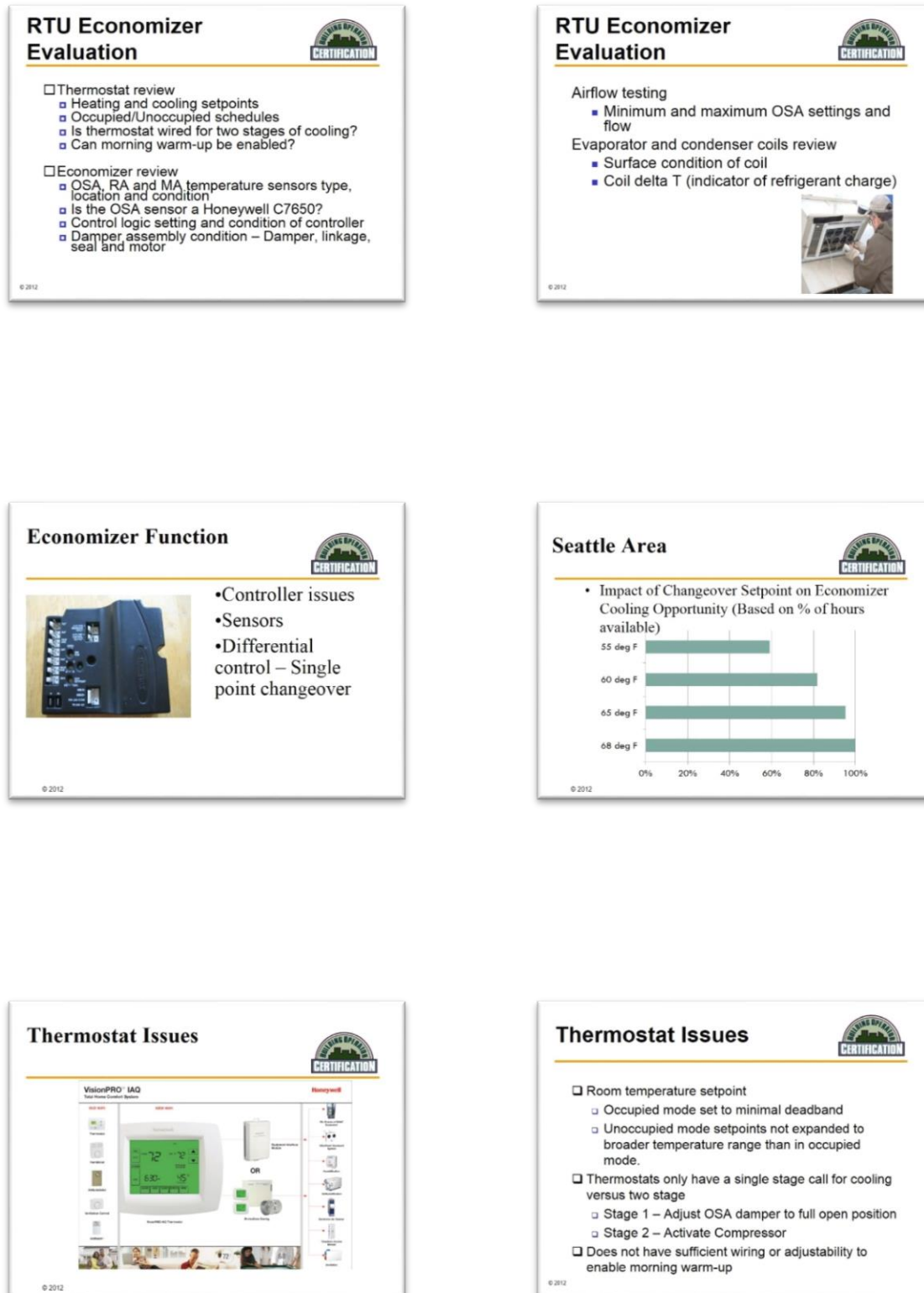



Figure 46: Presentation to SPEER, December 2012 (continued)

Presentation to ICEBO, October 2012

### STATEWIDE EMISSIONS REDUCTION, ELECTRICITY AND DEMAND SAVINGS FROM THE IMPLEMENTATION OF BUILDING-CODES IN TEXAS



Bahman Yazdani, P.E., C.E.M.  
Associate Director


Jeff S. Haberl, Ph.D., P.E.  
Professor/Associate Director

Hyojin Kim  
Research Engineering Associate


Juan-Carlos Baltazar, Ph.D.  
Associate Research Engineer

Gali Zilbershtein, Ph.D.  
Research Engineering Associate


12<sup>th</sup> International Conference for Enhanced Building Operations  
Manchester, UK, Oct 23-26, 2012



**Energy Systems Laboratory**



**Texas A&M Engineering Experiment Station**



**The Texas A&M University System**

12<sup>th</sup> International Conference for Enhanced Building Operations  
Manchester, UK, Oct 23-26, 2012

### Energy Systems Laboratory (ESL)

The Energy Systems Laboratory (ESL) conducts research and deploys a wide variety of energy efficient and renewable technologies to meet the needs of clients worldwide.

- Continuous Commissioning® (CC®)**
  - Improve comfort and increase energy efficiency in existing buildings
  - Optimize facility performance based on current use
  - Implemented in over 300 buildings
- Industrial Assessment Center (IAC)**
  - 25 years of continuous funding from the DOE
  - Trains undergraduate & graduate students to conduct no cost energy audits for regional manufacturing facilities
  - Performed over 600 audits
  - Recommendations made of over \$50 million in annual savings
- Riverside Energy Efficiency Laboratory (REEL)**
  - The official testing laboratory for the Home Ventilating Institute
  - An ISO 17025 (Laboratory Quality) certified laboratory
  - Serves global HVAC manufacturers
- Texas Emissions Reduction Plan (TERP)**
  - Assists the state in calculating emissions reduction benefits and in implementation of building energy standards
  - Dedicated to building energy modeling, building energy efficiency, review, assistance and training of energy codes, emissions reduction
  - Developed the International Code Compliance Calculator (ICC3), an online energy-performance software tool
  - Produced over 4,000 publications

Enhancing Performance, Reducing Emissions, Increasing Comfort & Improving Quality of Life. © 2012 Energy Systems Laboratory, The Texas A&M University System

### Texas Emissions Reduction Plan (TERP)

- In 2001, the 77th Texas Legislature passed Senate Bill 5 (SB5) defining the Texas Emissions Reduction Plan (TERP)
- The TERP Objectives**
  - Ensure that the air in Texas meets the Federal Clean Air Act requirements (US EPA Page)
  - Designated 43 counties as non-attainment and near non-attainment
  - Reduce Nitrous Oxides (aka NOx) emissions in non-attainment and near-non-attainment counties through mandatory and voluntary programs, including the implementation of energy efficiency and renewable energy programs (EE/RE)

Enhancing Performance, Reducing Emissions, Increasing Comfort & Improving Quality of Life. © 2012 Energy Systems Laboratory, The Texas A&M University System

### Texas Emissions Reduction Plan (TERP)

- TERP Key Provisions**
  - A diesel emissions reduction incentive program
  - A motor vehicle purchase or lease incentive program
  - A new technology research and development program
  - An energy efficiency grant program
  - A statewide Texas Building Energy Performance Standard (TBEPS) for all residential and commercial buildings
  - A goal of 5% per year reduction in electrical consumption for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2008

Enhancing Performance, Reducing Emissions, Increasing Comfort & Improving Quality of Life. © 2012 Energy Systems Laboratory, The Texas A&M University System

### ESL's Role in TERP

- Analyze the impact of several of the TERP programs for consideration in the State Implementation Plan (SIP).  
**Programs include:**
  - green power purchases, including wind and other renewable energy resources
  - the Public Utility Commission of Texas (PUC) energy efficiency programs
  - the State Energy Conservation Office (SECO) program for state agencies, political subdivisions and institutions of higher education
  - retrofits to federal buildings
  - furnace pilot light retrofits
  - residential air conditioner retrofits
  - residential and commercial construction
- Analysis focuses on:**
  - Energy savings
  - Creditable emissions reductions
  - Statewide / By county

*ESL has been named  
A National Center of Excellence  
on Displaced Emission  
Reductions for the US EPA*

Enhancing Performance, Reducing Emissions, Increasing Comfort & Improving Quality of Life. © 2012 Energy Systems Laboratory, The Texas A&M University System

Figure 47: Presentation to ICEBO, October 2012



Figure 47: Presentation to ICEBO, October 2012 (continued)





Figure 47: Presentation to ICEBO, October 2012 (continued)

Presentation to Clean Air Through Energy Efficiency Conference, October 2012, Galveston, Texas



Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference

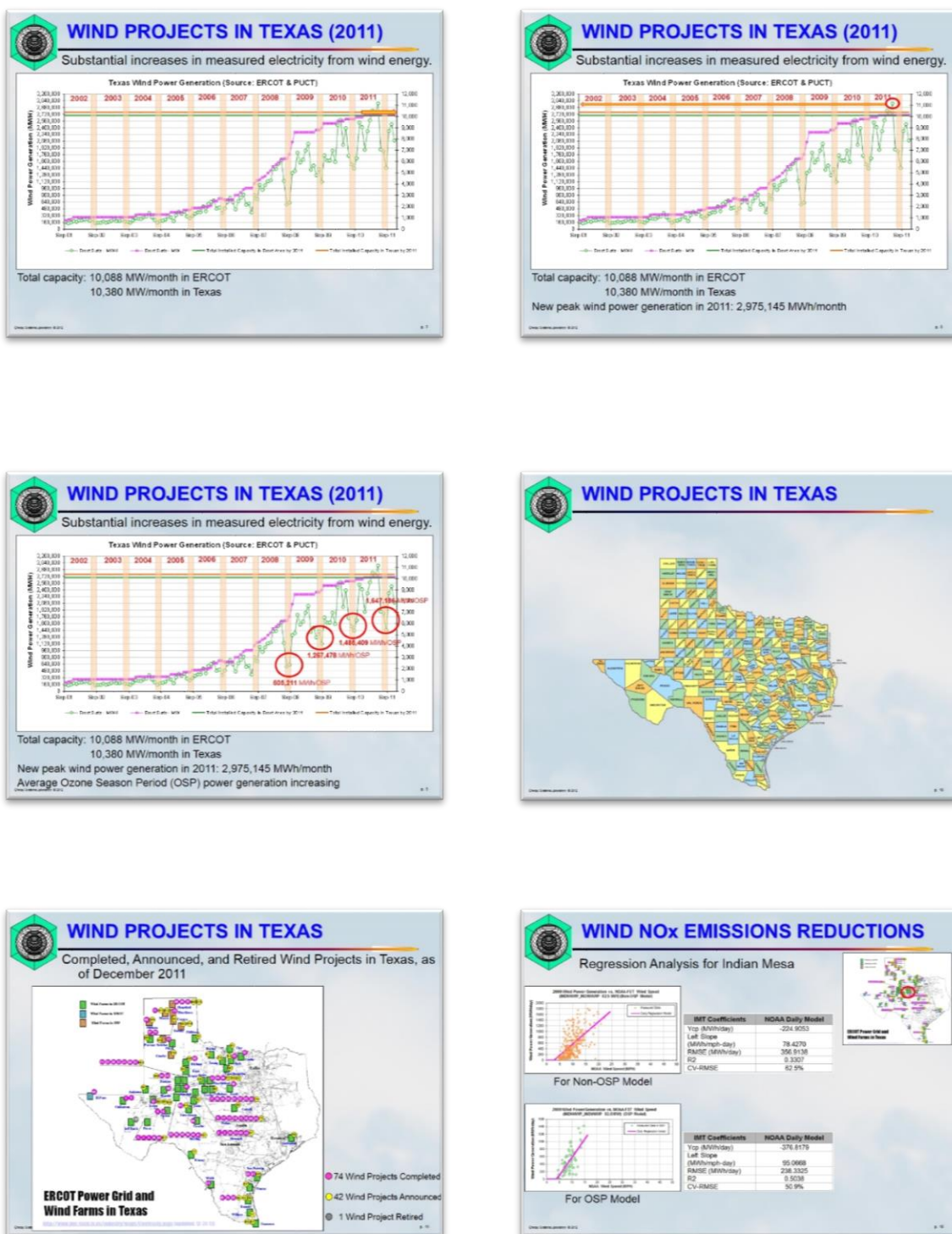


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (continued)

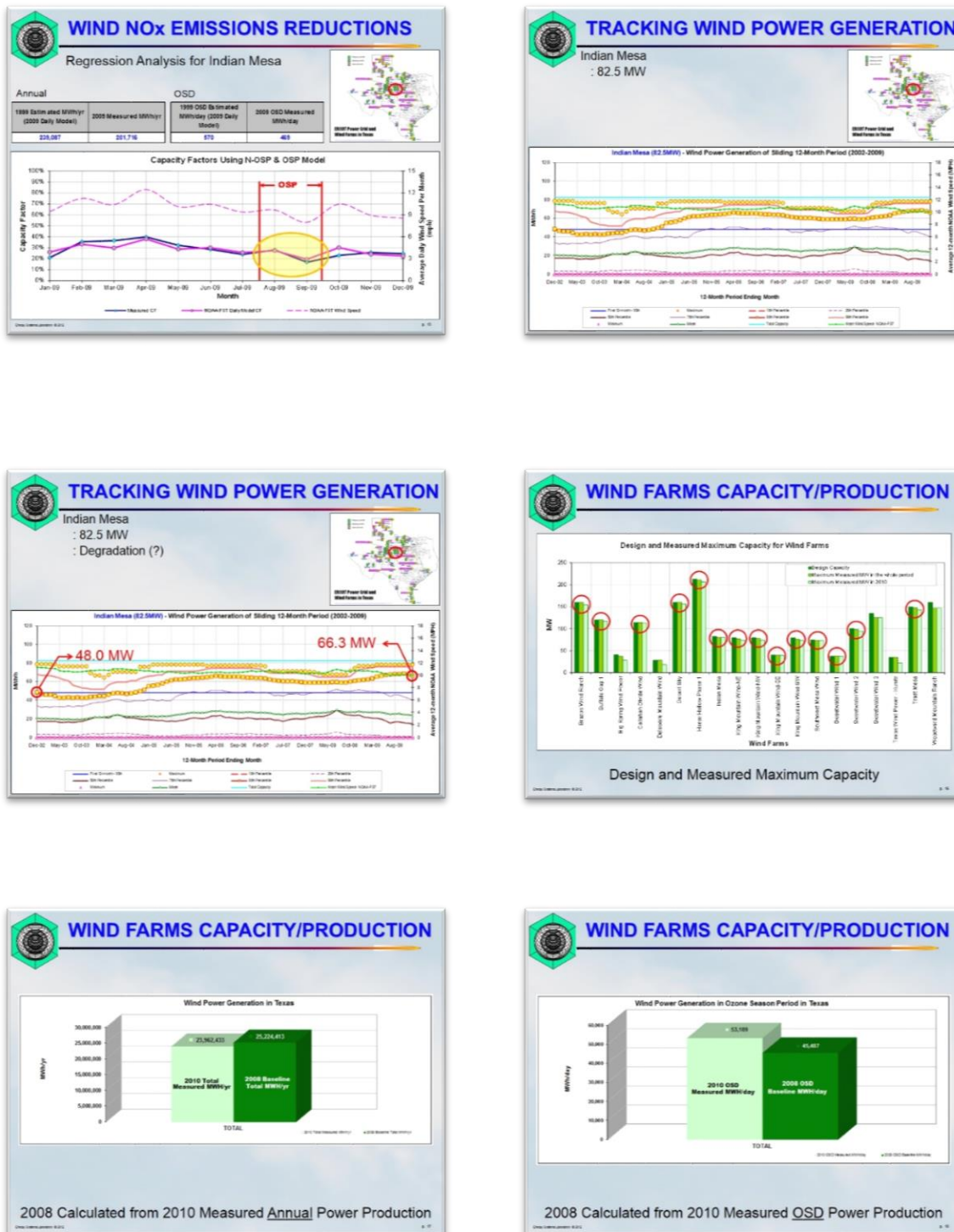


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)





Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)



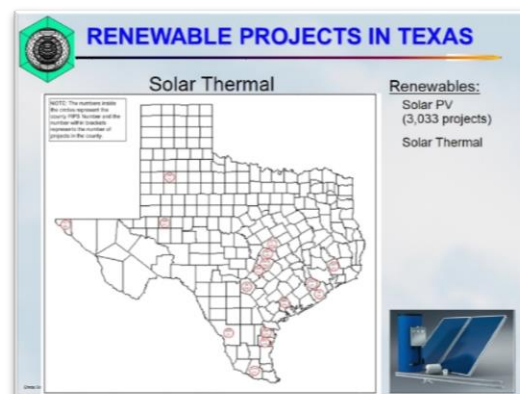
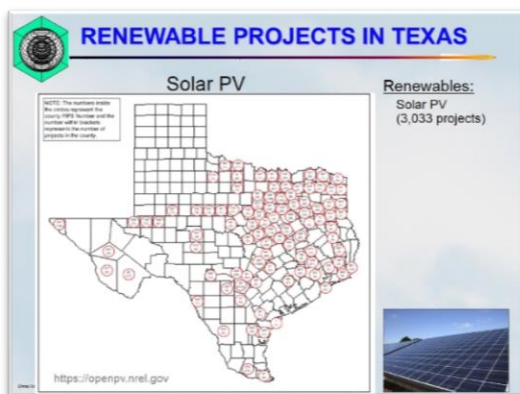
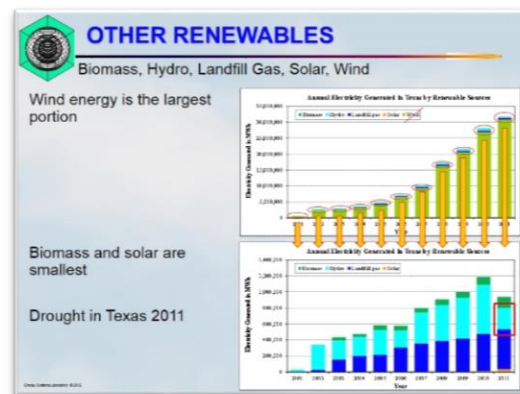
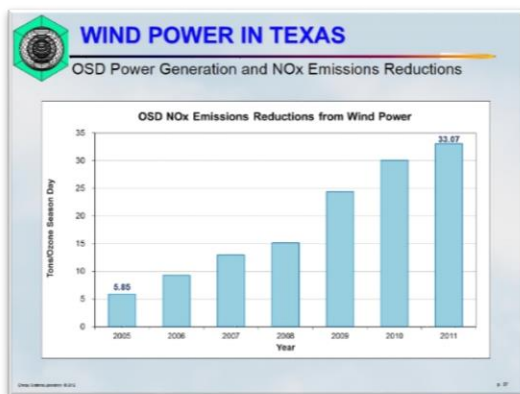
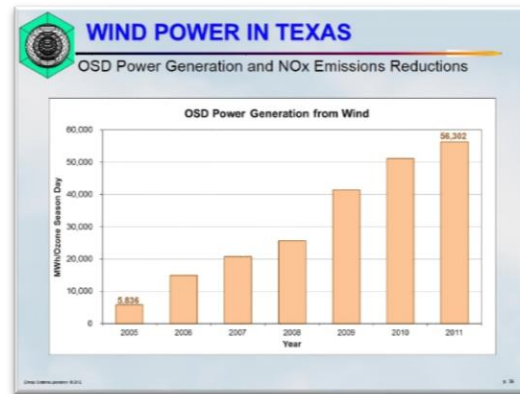
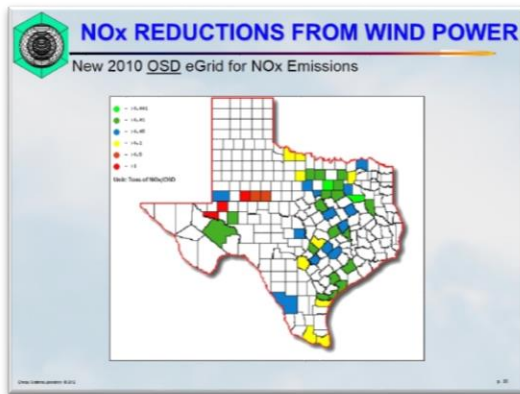


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

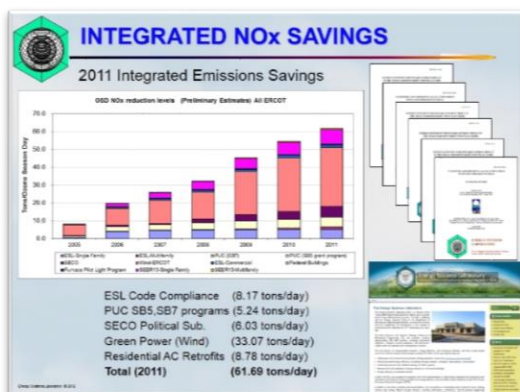
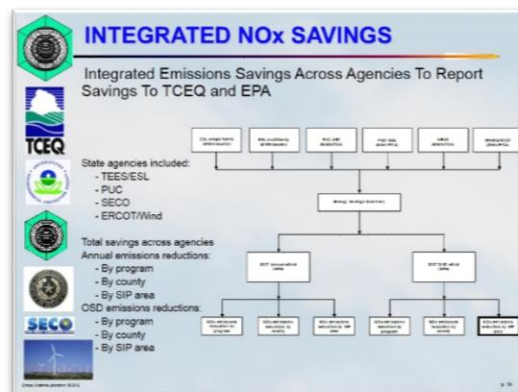
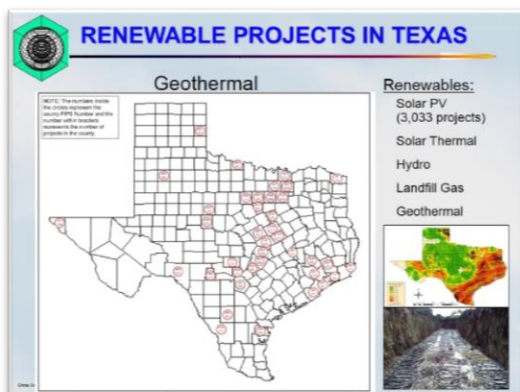
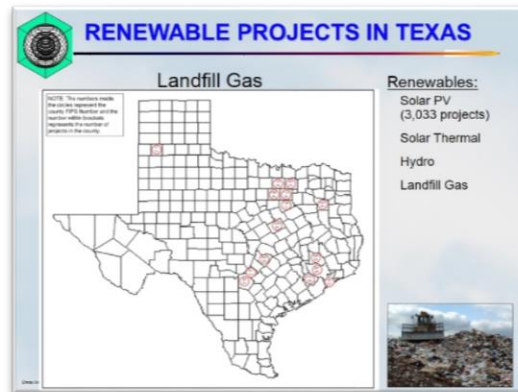
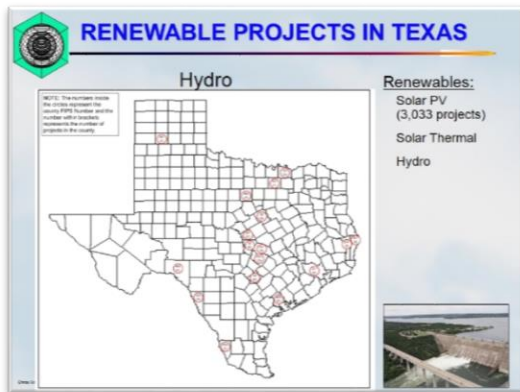



Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

**TEXAS EMISSIONS REDUCTIONS  
PROGRAM (TERP) ENERGY  
EFFICIENCY/RENEWABLE ENERGY  
(EE/RE) UPDATE**

October 2012

Jeff Haberl, Bahman Yazdani, Charles Culp  
Energy Systems Laboratory  
Texas A&M University

The Texas A&M University logo, featuring a green hexagon with a white border. Inside the hexagon is a circular seal with a star in the center and the words "TEXAS A&M UNIVERSITY" around the perimeter. The background of the slide is a blue sky with white clouds.

# ACKNOWLEDGEMENTS

**Faculty/Staff:** Juan-Carlos Baltazar, Jaya Mukhopadhyay, Hyojin Kim, Patrick Parker, Yv Reid, Gali Zilbershtein, Rose Sauser, Stephen O'Neal, Tammy Jennings, Larry Degelman, Ed Dryden, Shirley Muns, Tom Fitzpatrick

**Students:** Kee Han Kim, Sung Lok Do, Chunliu Mao, Jong-Hyo Choi, Simge Andolsun

**TCEQ:** Vince Meiller, Bob Gifford

**TPUC:** Katie Rich

**SECO:** Dub Taylor, Stephen Ross

**ERCOT:** Warren Lasher

**USEPA:** Art Diem, Julie Rosenberg

© 2014 California Department of Water Resources

[illegible]

**IC3: UPDATED TO IECC 2009**

**IC3** International  
CODE COMPLIANCE  
CALCULATOR

IC3 Updated to Version 3.12.0

**User Login**

Welcome! This is publicly accessible energy code compliance software based on the Texas Building Energy Performance Standards. You must register a username and password in order to continue. You may then access your records using your user name and password.

Email Address:

Password:

[Login](#)

[Register](#) [Forgot Password](#)

**HERO**

**RESNET**  
Building Energy Performance to Quality

**TEES**

**Login Screen**

The screenshot shows the 'Energy Code Compliance Program' software interface. The window title is 'Energy Code Compliance Program'. The interface includes a sidebar with navigation links: 'New Project', 'Open Project', 'Print', 'Help', 'About', 'Settings', 'Tools', 'Reports', 'Database', 'Help', 'About', 'Settings', 'Tools', 'Reports', 'Database'. The main area displays a project form with the following fields: 'Project Name' (text box), 'Address' (text box), 'City' (text box), 'State' (text box), 'Zip' (text box), 'County' (text box), 'Permit Number' (text box), 'Inspector' (text box), 'Date' (text box), 'Project Type' (text box), 'Project Status' (text box), 'Project Description' (text box), 'Project Location' (text box), 'Project Size' (text box). A 3D rendering of a house is displayed on the right side of the form.

[illegible]

Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference



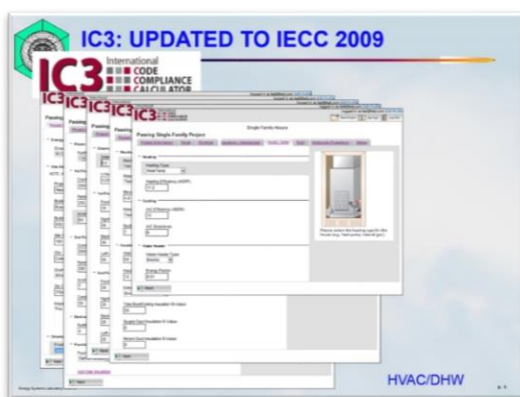
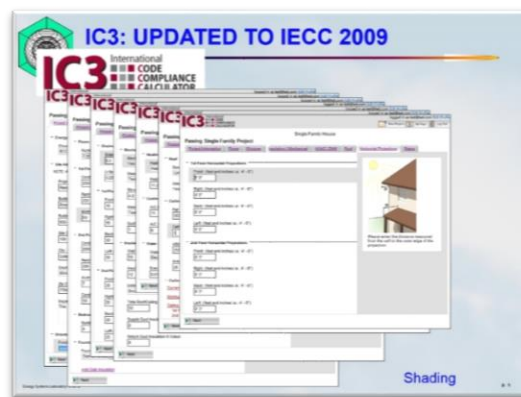
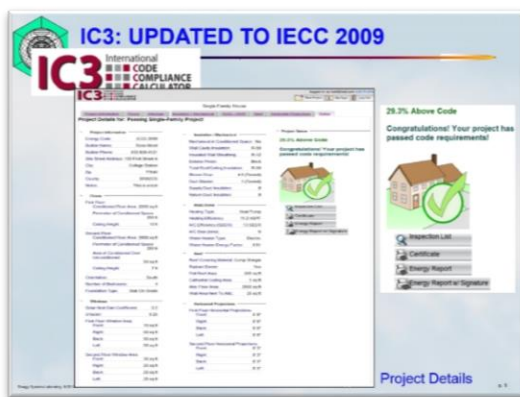
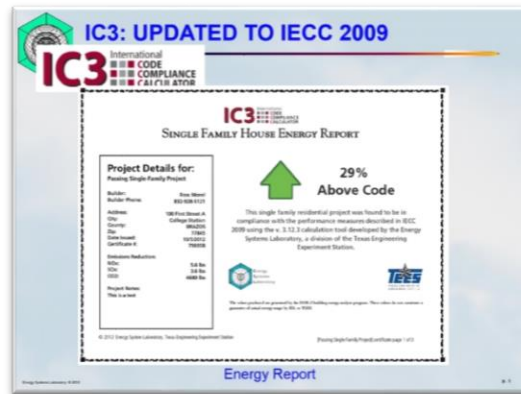
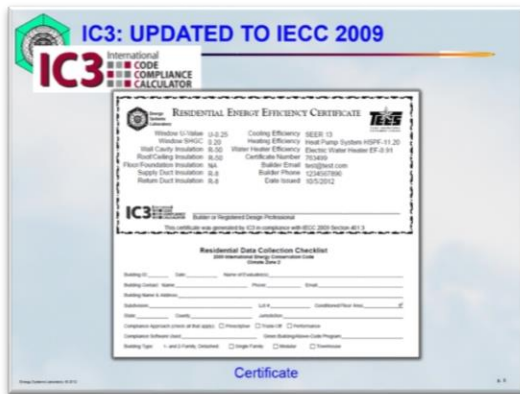


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)



Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)



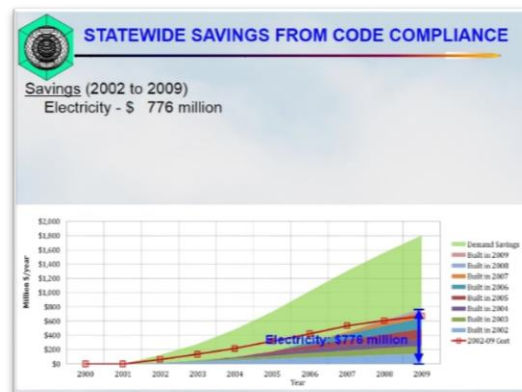
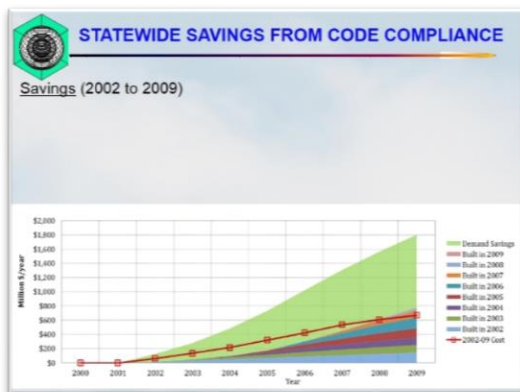
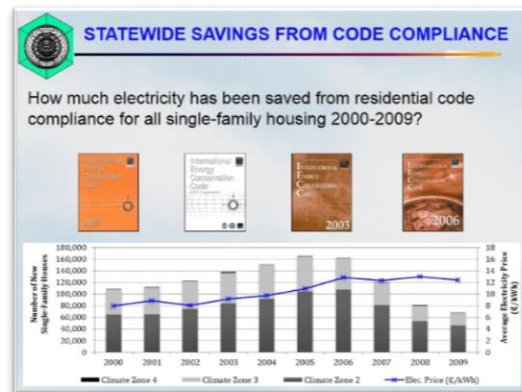
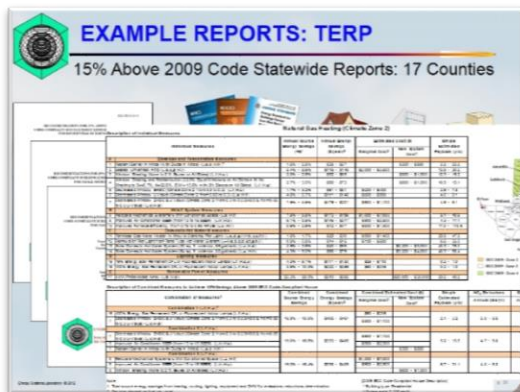
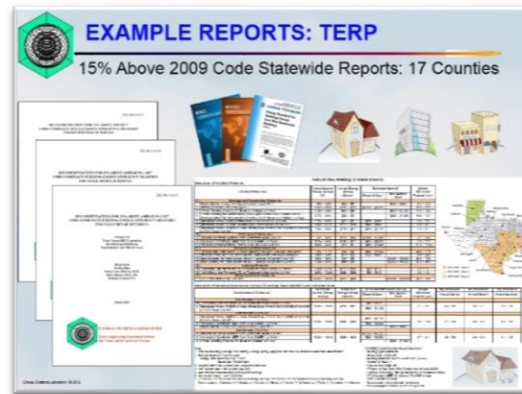
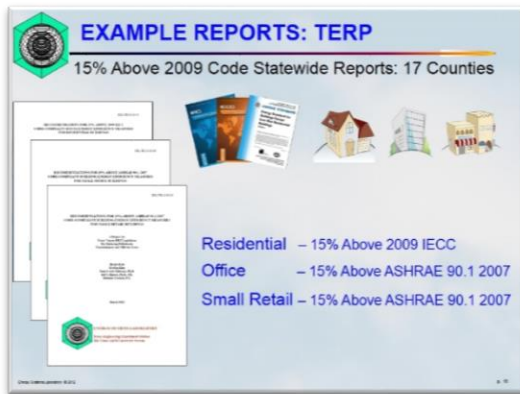


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

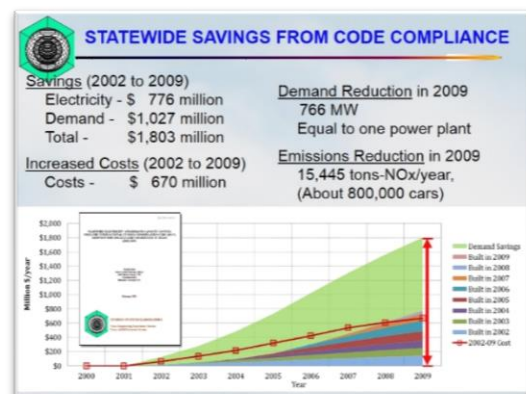
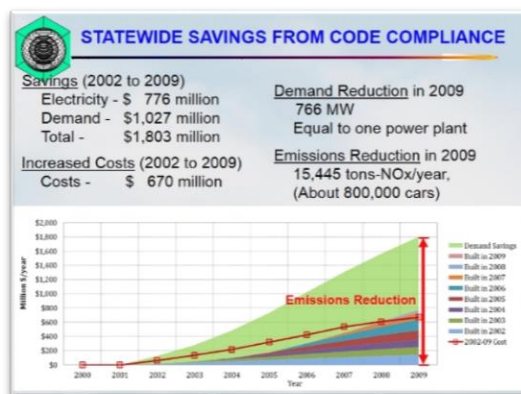
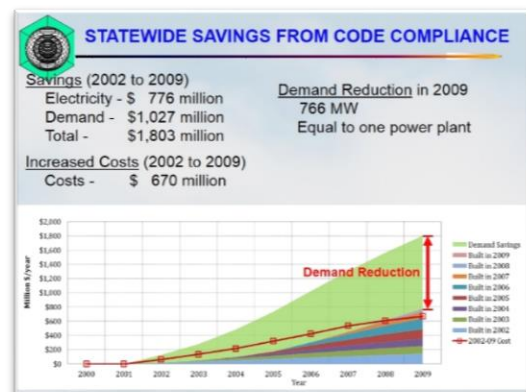
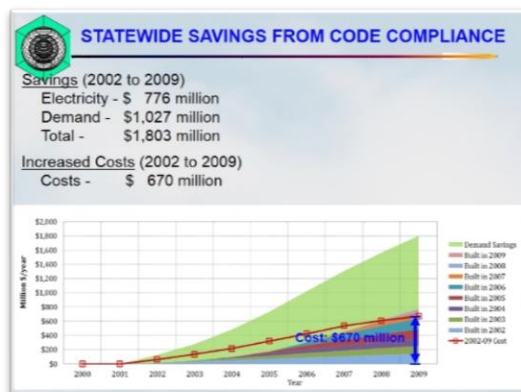
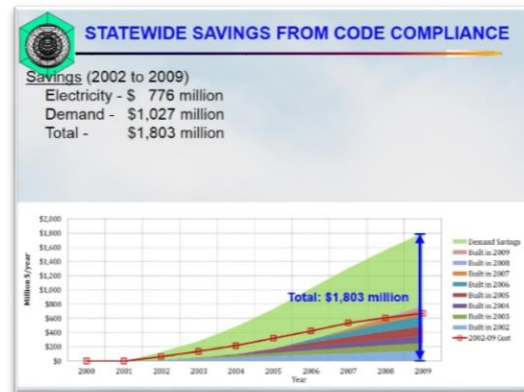
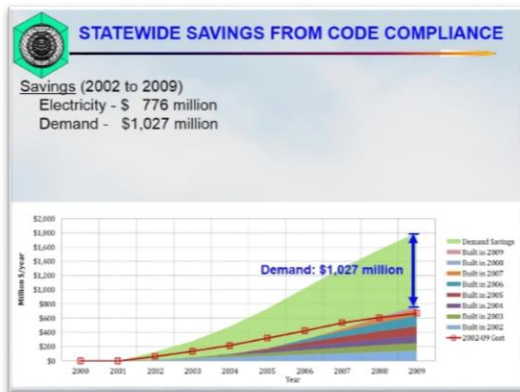


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

**2012 FEDERAL LIGHTING MANDATE**  
EISA 2007

GENERAL SERVICE INCANDESCENT LAMPS

Rated Lumen Ranges	Maximum Rate Wattage	Minimum Rate Lifetime	Effective Date
1490-2600	72	1,000 hrs	1/1/2012
1050-1489	53	1,000 hrs	1/1/2013
750-1049	43	1,000 hrs	1/1/2014
310-749	29	1,000 hrs	1/1/2014

EISA 2007 legislation

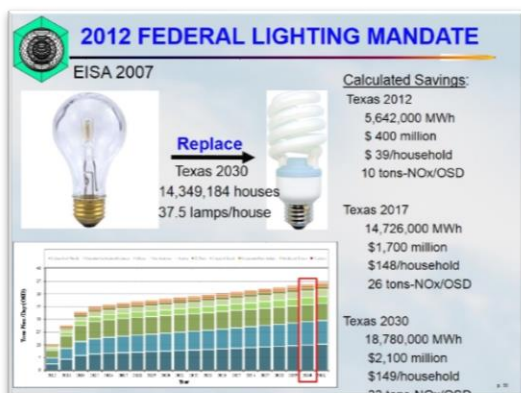
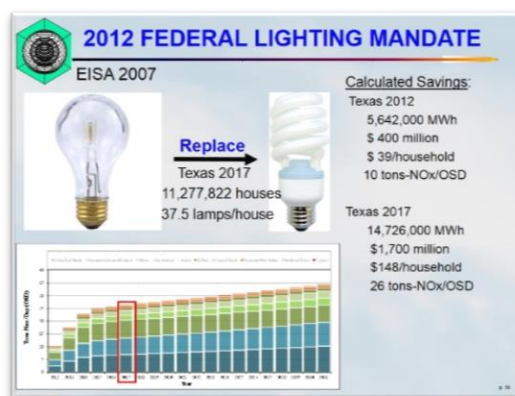
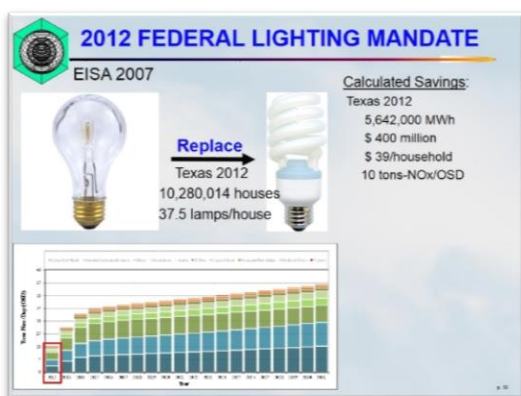


Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)



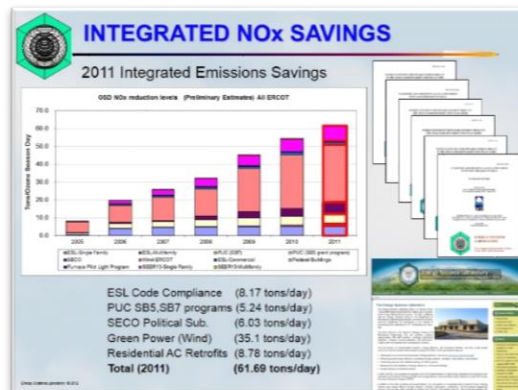
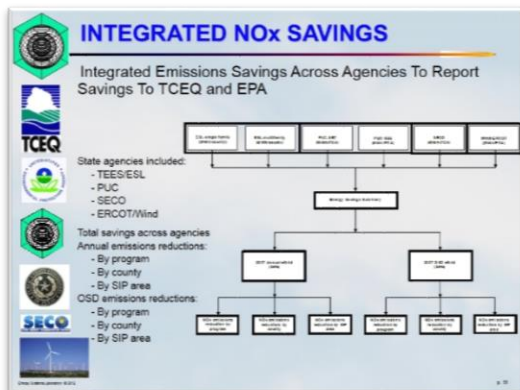
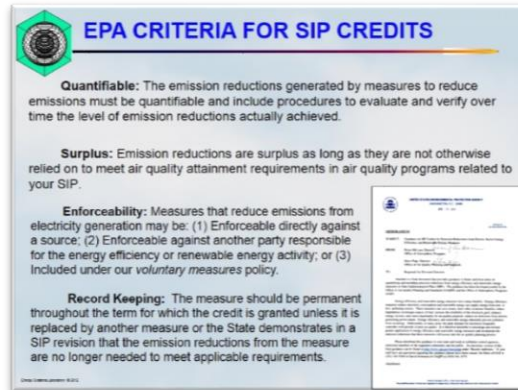
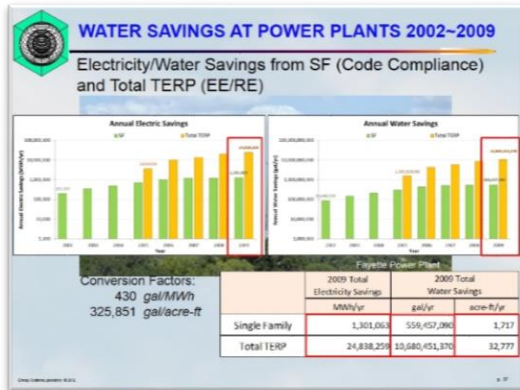



Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

## Energy Efficiency / Renewable Energy (EE/RE) Projects in Texas Public Schools: TOP Four Measures:

Hyojin Kim, Jeff Haberl, Jaya Mukhopadhyay,  
Juan-Carlos Baltazar, Sung Lok Do, Kee Han Kim, Bahman Yazdani  
Energy Systems Laboratory


James Yarborough, U.S.E.P.A.

Energy Systems Laboratory  
Texas A&M Engineering Experiment Station  
Texas A&M University System



## Background


- Texas A&M University's Energy Systems Lab, under contract from EPA, modeled 18 different EE/RE measures for schools throughout Texas, by climate zone.



Energy Systems Laboratory

## Background


- Texas A&M University's Energy Systems Lab, under contract from EPA, modeled 18 different EE/RE measures for schools throughout Texas, by climate zone.
- Looked at both retrofitting and new construction.



Energy Systems Laboratory

## Background


- Texas A&M University's Energy Systems Lab, under contract from EPA, modeled 18 different EE/RE measures for schools throughout Texas, by climate zone.
- Looked at both retrofitting and new construction.
- It assumed a 79,430 sq. ft. 1-story primary school in the modeling.



Energy Systems Laboratory

## Background


- Texas A&M University's Energy Systems Lab, under contract from EPA, modeled 18 different EE/RE measures for schools throughout Texas, by climate zone.
- Looked at both retrofitting and new construction.
- It assumed a 79,430 sq. ft. 1-story primary school in the modeling.
- Outputs:** Electricity, gas, and total energy savings; initial costs and payback periods for retrofits and new construction; also, air pollution emissions savings.



Energy Systems Laboratory

## Background

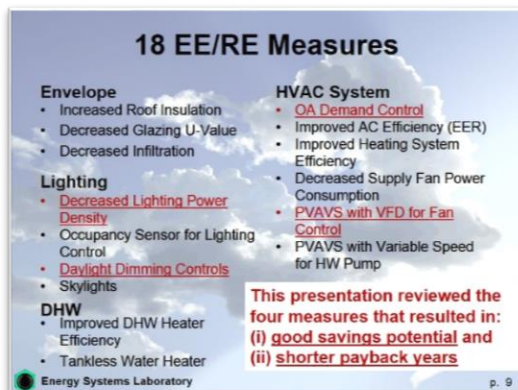
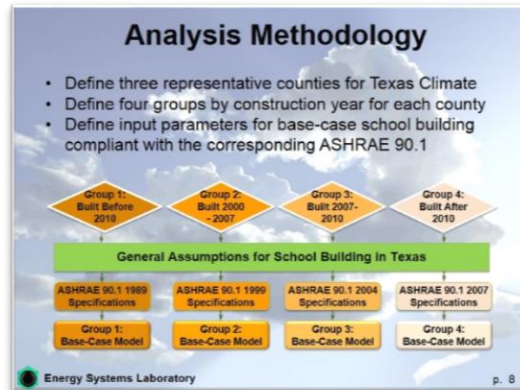
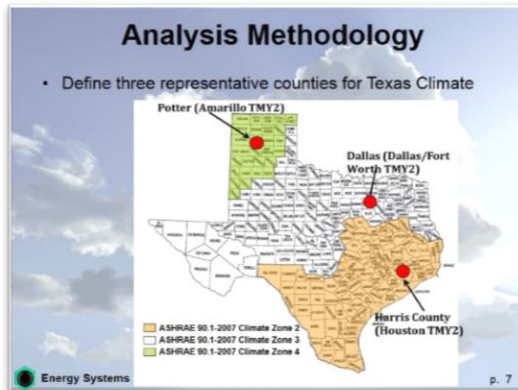
- Results published in Report (ESL-TR-10-08-01) available from Texas A&M University's Energy Systems Lab:  
<http://esl.eshwin.tamu.edu/docs/terp/2010/ESL-TR-10-08-01.pdf>



Energy Systems Laboratory

Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)





### Decreased LPD to 1.1 W/ft<sup>2</sup>

Retrofitting	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$1.00/sq. ft.	\$0.22/sq. ft.	4.6 years
Dallas (climate zone 3)		\$0.21/sq. ft.	4.7 years
Amarillo (climate zone 4)		\$0.18/sq. ft.	5.6 years
New Construction	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$0.16/sq. ft.	\$0.05/sq. ft.	3.1 years
Dallas (climate zone 3)		\$0.05/sq. ft.	3.1 years
Amarillo (climate zone 4)		\$0.04/sq. ft.	3.7 years

Energy Systems Laboratory p. 11



Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

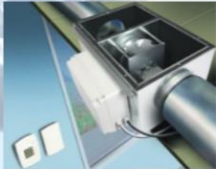
### Daylight Dimming Controls

Retrofitting	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$1.07/sq. ft.	\$0.25/sq. ft.	4.2 years
Dallas (climate zone 3)		\$0.25/sq. ft.	4.4 years
Amarillo (climate zone 4)		\$0.21/sq. ft.	5.1 years
New Construction	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$1.07/sq. ft.	\$0.19/sq. ft.	5.5 years
Dallas (climate zone 3)		\$0.17/sq. ft.	6.4 years
Amarillo (climate zone 4)		\$0.16/sq. ft.	6.7 years

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### OA Demand Controlled Ventilation (DCV)

- Utilizes CO<sub>2</sub> sensors to ventilate the building by actual occupancy
- High site energy savings in Amarillo (CZ 4) from NG heating energy savings (i.e., lower costs savings) for both retrofitting (9.2%) and new construction (9.6%)
- 4.4% to 4.8% site energy savings in Houston (CZ 2) and Dallas (CZ 3) from both electricity cooling and NG heating savings



Energy Systems Laboratory p. 14


### OA Demand Controlled Ventilation (DCV)

Retrofitting	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$0.61/sq. ft.	\$0.12/sq. ft.	5.0 years
Dallas (climate zone 3)		\$0.10/sq. ft.	6.3 years
Amarillo (climate zone 4)		\$0.09/sq. ft.	6.7 years
New Construction	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$0.61/sq. ft.	\$0.12/sq. ft.	5.1 years
Dallas (climate zone 3)		\$0.10/sq. ft.	6.3 years
Amarillo (climate zone 4)		\$0.09/sq. ft.	6.9 years

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### VFD for Fan Control

- Variable speed control for fans using Variable Frequency Drives (VFDs) that replaced inlet vanes
- One of the shortest payback measures: 2.9 to 3.1 yrs. for retrofitting and 3.3 to 3.4 yrs. for new construction
- 3.9% to 5.6% site energy savings across the counties
- Small NG heating energy penalty



Energy Systems Laboratory p. 16

### VFD for Fan Control

Retrofitting	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$0.50/sq. ft.	\$0.16/sq. ft.	3.1 years
Dallas (climate zone 3)		\$0.17/sq. ft.	3.0 years
Amarillo (climate zone 4)		\$0.17/sq. ft.	2.9 years
New Construction	Initial Cost	Annual Savings	Payback Years
Houston (climate zone 2)	\$0.50/sq. ft.	\$0.15/sq. ft.	3.4 years
Dallas (climate zone 3)		\$0.15/sq. ft.	3.4 years
Amarillo (climate zone 4)		\$0.15/sq. ft.	3.3 years

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### Summary

- Energy Efficiency / Renewable Energy (EE/RE) Projects in Texas Public Schools
- Of the 18 measures, this presentation reviewed the selected four measures that resulted in good savings potential as well as shorter payback years.
  - Decreased LPD
    - Daylight Dimming Controls
    - OA Demand Controlled Ventilation (DCV)
    - VFD for Fan Control

Energy Systems Laboratory p. 18

Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)


### Summary

- **Two lighting measures:** Electricity savings for lighting and cooling, but NG heating energy penalty
- **OA DCV measure:** Majority of savings from NG heating savings (i.e., lower cost savings compared to site energy savings)
- **VFD for fan control:** A constant site energy savings (3.9% to 5.6%) across the counties

PAYBACK YEARS	Retrofitting	New Construction
Decreased LPD	5 to 6 yrs.	3 to 4 yrs.
Daylight Dimming Controls	4 to 5 yrs.	6 to 7 yrs.
OA Demand Controlled Ventilation	5 to 7 yrs.	5 to 7 yrs.
VFD for Fan Control	3.0 yrs.	3.5 yrs.

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### Questions?



EEL-12-0001

ENERGY EFFICIENCY, COST EFFECTIVENESS, AND AIR QUALITY RISK: A COST-BENEFIT ANALYSIS FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY USE IN PUBLIC BUILDINGS

A Report to the U.S. EPA  
Through the University of Texas at Austin  
in Partial Fulfillment of the Requirements for the Master of Science Degree (M.Sc.)

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Energy Systems Laboratory, U.S. EPA  
KARL WATSON, Ph.D., P.E.  
Energy Systems Laboratory, U.S. EPA  
JAMES WATSON, Ph.D., P.E.  
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Figure 48: Presentation to the Clean Air Through Energy Efficiency Conference (Continued)

### 3.6.1 Presented one paper at the 2012 ICEBO Conference in Manchester, UK October 2012

One paper was prepared and presented at the 2012 ICEBO conference in Manchester, UK, October 2012. A copy of this paper has been posted on the Laboratory's TERP web page. Title and abstract for the paper is as follows.

Yazdani, B.; Haberl, J.; Kim, H.; Baltazar, J.C.; Zilbershtein, G. 2012 "Statewide Emissions Reduction, Electricity and Demand Savings from the Implementation of Building-Energy-Codes in Texas," *Proceedings of the 12<sup>th</sup> International Conference for Enhanced Building Operations*, Manchester, United Kingdom. This paper focuses on the estimate of electricity reduction and electric demand savings from the adoption of energy codes for single-family residences in Texas, 2002-2009, corresponding increase in construction costs and estimates of the statewide emissions reduction.

## 4. Calculated NOx Reduction Potential from the Implementation of the 2006 IECC and the ASHRAE Standard 90.1-2007

### 4.1 Calculated 2012 Electricity and Natural Gas Savings Due to the Implementation of the 2006 IECC to New Residential Construction (Single-family and Multi-family) and the ASHRAE Standard 90.1-2007 to New Commercial Construction Using Code-Traceable, Fuel-Neutral Simulation

A complete reporting of the savings from the implementation of the 2006 IECC and the ASHRAE Standard 90.1-2007 requires tracking and analyzing savings for new construction buildings that undergo a building permit. The adoption of the 2006 IECC and the ASHRAE Standard 90.1-2007 in Texas is expected to impact the following types of buildings:

- single-family residential
- multi-family residential
- commercial
- industrial

The following sections report the calculated energy savings associated with new construction activities for both residential (i.e., single-family and multi-family) and commercial construction. The calculation of energy savings from the adoption of the ASHRAE Standard 90.1-2007 in industrial buildings is currently under development at the Laboratory, and will be reported in future reports.

The following sections report the calculated energy savings associated with new construction activities for both residential (i.e., single-family and multi-family) and commercial construction.

#### 4.1.1 IC3 Enhancements

Most of the enhancements that are being added to IC3 in the recent years are summarized next:

#### **In version 3.12.x (January 2012)**

- Deprecated 2000/2001 and 2006 Houston Code.
- Added a button to generate Energy Report w/ a signature line. The original energy report still exists
- Improvements in the algorithm
- Help images/ text updated
- Updated manual

#### **In Version 3.11 (December 2011)**

- Added support for IECC 2009 Austin Amendments

#### **In Version 3.10 (September 2011)**

- Three IECC 2009 compliant reports (i.e. energy, inspection list, and certificate)
- Paging enhancements on “My Page” to help organize large quantities of projects.
- Multi-family usability increased with Plan/Unit information being displayed on pages.
- Elimination of flash animation (so we will become iPad compatible).
- Updated/expanded help text.
- Updated illustrations.
- Tweaked min/max values on duct insulation, water heaters.

#### **In Version 3.9.x (October 2010)**

- Added slab insulation
- Updated the manual

#### **In Version 3.8.x (September 2010)**

- Fixed default of Multi-family Units to be “Ducts in Conditioned Space” to YES
- Fixed wrong IECC code version on certificate
- Enhanced input screens by moving several fields from Units to Floor Plans

#### **In Version 3.7.x (June 2010)**

- Simple multi-family code compliance
- Updated model
  - a. Floor Insulation R-Value
  - b. Four foundation types
- Updated illustrations
- Updated manual

#### **In Version 3.6.2 (April 2010)**

- Fixed defect in 2nd Floor, Back Window issue
- Reference A\C tonnage matches the proposed A\C tonnage.
- Updated model
- Updated illustrations

#### **In Version 3.6.1 (December 2009)**

- Foundations
- Opt out of emails
- Copy a project
- Moved orientation from Floors tab to Project Information

#### **In Version 3.5.2 (November 2009)**

- Three code choices: IECC 2009, IECC 2006 (with Houston Amendments) and IECC 2000/2001.
- Duct insulation values
- Improved input of overhang values to allow for just inches

#### 4.1.2 Changes in single family input file

There has been one major version change according to the changes in the single family input file since the 2010 annual simulations. Table 2 presents the summarized description of the changes in single family input file since the 2010 annual simulation.

Table 2: Changes in single family input file

BDL Version	Description
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4.01.07	BDL used for the 2010 annual report.
4.01.08	Modified cooling and heating Energy-Input-Ratio (EIR) calculation methodology. Corrected door insulation to meet the requirements of 2006 IECC and 2009 IECC.

## Version 4.01.08

Modified cooling and heating Energy-Input-Ratio (EIR) calculation methodology

The first change in the input file was to modify cooling and heating Energy-Input-Ratio calculation methodology from SEER and HSPF. The energy efficiency of residential air conditioning systems is rated by the SEER (or HSPF for heat pumps in a heating season) which already includes fan power. Thus if COOLING-EIR or HEATING-EIR for DOE-2.1e inputs are calculated using the nominal SEER or HSPF of the systems, then SUPPLY-KW should be set to zero. Otherwise, if the fan is modeled separately, the fan power should be excluded in the input energy use for EIR calculations.

Since the fan runs continuously during occupied hours in IC3, to model fan power separately is recommended rather than including fan energy in EIRs. Therefore, to determine EIRs for DOE-2 input, the ARI default value of 0.365 W/cfm can be assumed for fan power and subtracted from the input energy for each system (Fairey et al. 2004<sup>13</sup>). Based on 0.365 W/cfm, the following changes were made:

**[Version 4.01.07]**

##SET1 P-SEER sy04

##SET1 P-HSPF sy06

##SET1 P-EIR #[P-COOL-EIR-F[] \* #[3.41 / P-SEER[]]]

##SET1 P-HIR #[P-HEAT-EIR-F[] \* #[3.41 / P-HSPF[]]]

**[Version 4.01.08]**

##SET1 P-SEER sy04

##SET1 P-HSPF sy06

##SET1 P-SEER-NOFAN #[1 / #[1 / P-SEER[]] - 0.01095]]

\$ 0.01095 Wh/Btu = 0.365 W/cfm \* 360 cfm/ton \* 1 ton/12,000 Btu/h

\$ Fan power = 0.365 W/cfm (Fairey et al. 2004)

##SET1 P-HSPF-NOFAN #[1 / #[1 / P-HSPF[]] - 0.01095]]

\$ 0.01095 Wh/Btu = 0.365 W/cfm \* 360 cfm/ton \* 1 ton/12,000 Btu/h

\$ Fan power = 0.365 W/cfm (Fairey et al. 2004)

##SET1 P-EIR #[P-COOL-EIR-F[] \* #[3.41 / P-SEER-NOFAN[]]]

##SET1 P-HIR #[P-HEAT-EIR-F[] \* #[3.41 / P-HSPF-NOFAN[]]]

Corrected door insulation to meet the requirements of 2006 IECC and 2009 IECC

The change in the input file was to modify glitch in code for door insulation to meet the requirements of 2006 IECC and 2009 IECC performance path analysis. The change in the input file includes assigning door insulation to be

<sup>13</sup> Fairey, P., D.S. Parker, B. Wilcox and M. Lombardi. 2004. Climate Impacts on Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) for Air Source Heat Pumps. *ASHRAE Transactions* 110(2):178-188.

same as window U-value for a 2006 IECC or 2009 IECC code-compliant house and to be same as user input U-value for a proposed house.

**[Version 4.01.07]**

```
DOORCON-1 = CONSTRUCTION          $ MODIFIED BY JAYA M. 06/18/2007
  ##IF #[AMENDMENT[] EQS IC3]      $ TO INCORPORATE REQUIREMENTS FOR DOOR
    U = 0.2                        $ IN IECC2006 / TCV Table 404.5.2 of IECC 2006
  ##ELSEIF #[AMENDMENT[] EQS TCV]
    U = P-WINDOWU[]
  ##ENDIF
```

**[Version 4.01.06]**

```
DOORCON-1 = CONSTRUCTION          $ MODIFIED BY JAYA M. 06/18/2007
  ##IF #[P-INPUTMETHOD[] EQS S01] $ MODIFIED BY H.KIM 03/10/2011
    U = 0.2
  ##ELSEIF #[P-INPUTMETHOD[] EQS S06] OR #[P-INPUTMETHOD[] EQS S09]]
    U = P-WINDOWU[]
  ##ELSEIF #[P-INPUTMETHOD[] EQS U]
    U = P-DOORU[]
  ##ENDIF
```

#### 4.1.3 2012 Results for New Single-family Residential Construction

This section provides the potential electricity and natural gas reductions and the associated emissions reductions from the implementation of the 2006 IECC for new single-family residences in the 41 non-attainment and affected counties as well as other counties in the ERCOT region<sup>14</sup>. To calculate the NOx emissions reductions from the implementation of the 2006 IECC, the following procedures were adopted. First, new construction activity was determined by county, and energy savings attributable to the 2006 IECC were calculated using the Laboratory's code-traceable, DOE-2.1e simulation, which was developed for the TERP. These estimates were then applied to the NAHB Builder's survey data to determine the appropriate number of housing types. Then the NOx reduction potential from the electricity and natural gas reductions in each county was calculated using the US EPA's 2010 eGRID database<sup>15</sup>.

In Table 3, the 2012 and the 2006 IECC code-compliant building characteristics are shown for each county. The 2012 building characteristics reflect those published by the NAHB, ARI and GAMA for Texas. The 2006 IECC code-compliant characteristics are the minimum building code characteristics required by the 2006 IECC for each county for single-family residences (i.e., Type A.1). In Table 3, the rows are sorted first by the US EPA's non-attainment, affected designation, and then other ERCOT counties alphabetically. Next, in the fourth column, the NAHB Builder's survey classification is listed. The fifth, sixth, seventh, and eighth columns show the NAHB Builder's survey average glazing U-value, Solar Heat Gain Coefficient (SHGC), roof insulation and wall insulation, respectively. In columns nine through twelve, the corresponding values from the 2006 IECC code-compliant house are listed for each county (i.e., glazing U-value, SHGC, roof and wall insulation R-value).

The 2006 IECC SHGC is 0.4 for all non-attainment and affected counties as required by the 2006 IECC. All the 2012 houses were assumed to have air-conditioner efficiency equal to a SEER 13, furnace efficiency (AFUE) of 0.80, and a domestic water heater efficiency of 76%. All the 2006 IECC code-compliant houses were assumed to have air-conditioner efficiency equal to a SEER 13<sup>16</sup>. The values shown in Table 3 represent the only changes that were made to the simulation to obtain the savings calculations. All other variables in the simulation remained the same for the 2012 and the 2006 IECC code-compliant simulation. In cases where the 2012 values were more efficient than the 2006 IECC code-compliant simulation, the 2012 values were used in both simulations, since this indicates that the prevailing practice is already above code. For example, in Collin County, according to the NAHB

<sup>14</sup>The three new counties, Henderson, Hood and Hunt were added in the 2003 Legislative session are included in this.

<sup>15</sup> This preliminary analysis does not include actual power transfers on the grid, and assumes transmission and distribution losses of 7%. Counties were assigned to utility service districts as indicated.

<sup>16</sup> Based on the regulation effective.

Builder's survey data, the wall insulation is R-15.84, which is already above the code-required insulation of R-13. Therefore, R-15.84 was used in both simulations.

The code-traceable simulation results are shown for each county. In a similar fashion as Table 3, Table 4, is first divided into the US EPA's non-attainment and affected classifications, followed by an alphabetical listing of other ERCOT counties. In the third column of Table 4, the 2006 IECC climate zone is listed followed by the number of projected new housing units<sup>17</sup> in the fourth column. In the fifth column, the total simulated energy use is listed if all new construction had been built to pre-code specifications, and, in the sixth column, the total county-wide energy use for code-compliant construction is shown. The values in the fifth and sixth columns come from the associated 24 simulations runs for each county, which were then distributed according to the NAHB Builder's survey data to account for 1 story, 2 story, slab-on-grade, crawlspace, and three different system types. In the seventh column, the total annual electricity savings are shown for each county, respectively. A 7% transmission and distribution loss is used in the 2012 report, which represents a fixed 1.07 multiplier for the electricity use. In the eighth and ninth columns, the total annual pre-code and code-compliant natural gas use is shown for those residences that had natural gas-fired furnaces and domestic water heaters. Finally, in tenth column, the total annual natural gas savings are shown for each county.

In Table 5, the Congestion Management (CM) Zones<sup>18</sup> assignments for each county are shown. In Table 6, the annual electricity savings are assigned to CM Zones provider(s) according to Table 5. The total electricity savings for each CM Zone, as shown in then entered into the bottom row of Table 7, which is the 2010 US EPA's eGRID database<sup>19</sup> for Texas. eGRID then proportions each MWh of electricity savings according to the 2008 measured data from the power plants assigned to that CM Zones. For each county in which there is a power plant the lbs-NOx/MWh are calculated and displayed as NOx reductions (lbs) in the column adjacent to the CM Zones column. Adding across the rows then totals the NOx reductions in each county from multiple CM Zones that have power plants in that county. Counties that do not show NOx reductions represent counties that do not have power plants in eGRID's database.

<sup>17</sup> The number of projected new housing units uses the published values for the new housing units in 2012. A vacancy rate of 0% was assumed for 2012 calculations, based on information suggested by the Real Estate Center at Texas A&M University.

<sup>18</sup> ERCOT region has employed the Congestion Management (CM) since 2010, and it is currently divided into four zones, Houston (H), North (N), South (S), and West (W).

<sup>19</sup> This preliminary analysis does not include actual power transfers on the grid, and assumes transmission and distribution losses of 7%. Counties were assigned to CM Zones as indicated.

Table 3: 2012 and the 2006 IECC Code-compliant Building Characteristics used in the DOE-2 Simulations for Single-family Residential Buildings

	COUNTY	Climate Zone	Division (East or West)	2012 Average				2006 IECC			
				Glazing U-value (Btu/hr-ft2-F)	SHGC	Roof Insulation (hr-ft2-F/Btu)	Wall Insulation (hr-ft2-F/Btu)	Glazing U-value (Btu/hr-ft2-F)	SHGC	Roof Insulation (hr-ft2-F/Btu)	Wall Insulation (hr-ft2-F/Btu)
Non-attainment	Brazoria	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Chambers	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Collin	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Dallas	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Denton	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	El Paso	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Fort Bend	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Galveston	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Hardin	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Harris	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Jefferson	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Liberty	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Montgomery	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Orange	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Tarrant	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Waller	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
Affected	Bastrop	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Bexar	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Caldwell	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Comal	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Ellis	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Griggs	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	Guadalupe	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Harrison	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	Hays	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Henderson	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	Hood	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Hunt	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Johnson	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Kaufman	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Nueces	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Parker	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Rockwall	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Rusk	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	San Patricio	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Smith	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	Texas	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Upshur	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	Victoria	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	Williamson	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	Wilson	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
ERCOT	ANDERSON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	ANDREWS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	ANGELINA	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	ARANSAS	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	ARCHER	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	ATASCOSA	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	AUSTIN	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	BANDERA	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	BASTROP	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	BAYLOR	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	BEE	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	BELL	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	BEXAR	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	BLANCO	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	BORDEN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	BOSQUE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	BRAZORIA	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	BRAZOS	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	BREWSTER	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	BRISCOE	4	West Texas	0.44	0.53	25.29	14.74	0.65	NR	30	13.00
	BROOKS	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	BROWN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	BURLESON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	BURNET	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CALDWELL	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	CALHOUN	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	CALLAHAN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CAMERON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	CHAMBERS	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	CHEROKEE	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	CHILDRESS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CLAY	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CONE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	COLUMAN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	COLLIN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	COLORADO	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	COMAL	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	COMANCHE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CONCHO	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	COOKE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CORYELL	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	COTTLE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CRANE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CROCKETT	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CROSBY	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	CULBERSON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	DALLAS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	DAWSON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	DE WITT	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	DELTA	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	DENTON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	DICKENS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	DIMMIT	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	DUVAL	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	EASTLAND	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	ECTOR	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	EDWARDS	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	ELLIS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	ERATH	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	FALLS	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	FANNIN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	FAYETTE	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	FISHER	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	FOARD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	FORT BEND	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	FRANKLIN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	FREESTONE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00

Table 8: 2012 and the 2006 IECC Code-compliant Building Characteristics used in the DOE-2 Simulations for Single-family Residential Buildings (Continued)



	COUNTY	Climate Zone	Division (East or West)	2012 Average				2006 IECC			
				Glazing U-value (Btu/hr-ft <sup>2</sup> -F)	SHGC	Roof Insulation (hr-ft <sup>2</sup> -F/Btu)	Wall Insulation (hr-ft <sup>2</sup> -F/Btu)	Glazing U-value (Btu/hr-ft <sup>2</sup> -F)	SHGC	Roof Insulation (hr-ft <sup>2</sup> -F/Btu)	Wall Insulation (hr-ft <sup>2</sup> -F/Btu)
	FRIO	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	GALVESTON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	GILLESPIE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	GLASSCOCK	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	GOLIAD	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	GONZALES	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	GRAYSON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	GRIMES	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	GUADALUPE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	HALL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HAMILTON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HARDEMAN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HARRIS	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	HASKELL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HAYS	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	HENDERSON	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	HIDALGO	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	HILL	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	HOOD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HOPKINS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HOUSTON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	HOWARD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HUBBARD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	HUNT	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	IRION	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	JACK	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	JACKSON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	JEFF DAVIS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	JIM HOGG	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	JIM WELLS	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	JOHNSON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	JONES	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KARNES	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	KAUFMAN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KENDALL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KENEDY	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	KENT	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KERR	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KIMBLE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KING	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	KINNEY	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	KLEBERG	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	KNOX	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	LA SALLE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	LAMAR	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	LAMPASAS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	LAVACA	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	LEE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	LEON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	LIMESTONE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	LIVE OAK	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	LLANO	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	LOVING	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MADISON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	MARTIN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MASON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MATAGORDA	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	MAVERICK	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	MCALLACH	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MCINNIS	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	MCNULLEN	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	MEDINA	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	MENARD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MIDLAND	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MILAM	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	MILLS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MITCHELL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MONTAGUE	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MONTGOMERY	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	MOTLEY	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	MACDOUGHER	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	NAVARO	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	NOLAN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	NUECES	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	PALO PINTO	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	PARKER	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	PECOS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	PRESIDIO	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	RAINS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	REAGAN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	REAL	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	RED RIVER	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	REEVES	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	REFUGIO	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	ROBERTSON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	ROCKWALL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	RUNNELS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	RUSK	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	SAN PATRICIO	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	SAN SABA	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	SCHLEICHER	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	SCURRY	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	SHOCKEYFORD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	SMITH	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	SOMERVELL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	STARR	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	STEPHENS	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	STERLING	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	STONEWALL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	SUTTON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	TARRANT	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	TAYLOR	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	TERRELL	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	THROCKMORTON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	TITUS	3	East Texas	0.44	0.53	28.17	14.56	0.65	0.40	30	13.00
	TOM GREEN	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	TRAVIS	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	UPTON	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	UVALDE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	VAL VERDE	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	VAN ZANDT	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	VICTORIA	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	WALLER	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	WARD	3	West Texas	0.44	0.53	25.29	14.74	0.65	0.40	30	13.00
	WASHINGTON	2	East Texas	0.44	0.53	28.17	14.56	0.75	0.40	30	13.00
	WEBB	2	West Texas	0.44	0.53	25.29	14.74	0.75	0.40	30	13.00
	WHEATON	2	East Texas	0.44							

2012 Summary										TRY 2008
	County	Climate Zone	No. of Projected Units (2012)	Precode Total Annual Elec. Use (MWh/yr)	Code-compliance Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	Precode Total NG Use (Therm/yr)	Code-compliance Total NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)	
Nonattainment County	BRAZORIA	3	1,922	26,313	24,878	1,536	381,744	360,227	21,517	
	CHAMBERS	4	293	3,921	3,712	223	60,017	56,923	3,093	
	COLLIN	6	6,140	105,744	99,157	7,047	909,058	805,413	103,645	
	DALLAS	5	3,531	60,753	56,972	4,046	525,111	465,091	60,019	
	DENTON	6	3,460	59,588	55,877	3,971	512,271	453,865	58,406	
	EL PASO	6	3,176	48,545	45,758	2,962	534,714	467,193	67,521	
	FORT BEND	4	6,517	89,240	84,365	5,216	1,292,872	1,221,436	71,436	
	GALVESTON	3	1,784	24,424	23,092	1,426	354,334	334,363	19,971	
	HARDIN	4	95	1,272	1,204	72	19,456	18,418	1,038	
	HARRIS	4	14,550	199,239	188,355	11,646	2,886,496	2,727,005	159,491	
	JEFFERSON	4	539	7,218	6,833	412	110,386	104,498	5,888	
	LIBERTY	4	165	2,261	2,137	132	32,733	30,886	1,847	
	MONTGOMERY	4	3,364	46,064	43,548	2,693	667,366	630,491	36,875	
	ORANGE	4	184	2,464	2,333	141	37,640	35,673	1,967	
	TARRANT	5	4,640	79,834	74,865	5,316	690,035	611,165	78,870	
	WALLER	4	8	110	104	6	1,587	1,499	88	
	BASTROP	4	44	649	611	41	11,552	10,232	1,320	
	BEXAR	4	2,873	45,265	42,930	2,498	298,946	267,787	31,159	
	CALDWELL	4	6	100	94	6	772	684	88	
	Affected County	COMAL	4	1,130	17,803	16,885	983	117,580	105,325	12,255
ELLIS		5	643	11,063	10,375	737	95,623	84,694	10,930	
GREGG		6	228	3,413	3,217	210	60,692	57,375	3,317	
GUADALUPE		4	730	11,501	10,908	635	75,959	68,042	7,917	
HARRISON		6	36	537	507	33	9,679	9,132	547	
HAYS		5	1,426	23,686	22,255	1,530	182,987	162,317	20,670	
HENDERSON		5	146	2,176	2,053	132	39,352	37,134	2,218	
HOOD		5	113	1,944	1,823	129	16,805	14,884	1,921	
HUNT		6	26	448	420	30	3,858	3,419	439	
JOHNSON		5	558	9,601	9,003	639	82,983	73,498	9,485	
KAUFMAN		6	6	7,772	7,317	251	32,424	28,727	3,697	
NUECES		3	1,014	14,665	13,801	924	178,233	168,899	9,334	
PARKER		6	189	3,255	3,052	217	27,982	24,792	3,190	
ROCKWALL		6	675	11,625	10,901	775	99,937	88,543	11,394	
RUSK		5	4	54	51	3	961	903	58	
SAN PATRICIO		3	170	2,459	2,314	155	29,881	28,316	1,565	
SMITH		5	228	3,398	3,206	206	61,454	57,989	3,465	
TRAVIS		5	4,428	73,548	69,107	4,751	568,211	504,025	64,186	
UPSUR		6	13	199	187	13	3,946	3,492	454	
ERCOT		VICTORIA	3	111	1,554	1,466	94	21,980	20,736	1,244
	WILLIAMSON	5	2,357	39,149	36,786	2,529	302,455	268,290	34,166	
	WILSON	4	27	425	403	23	2,809	2,517	292	
	ANDERSON	5	6	80	76	5	1,441	1,354	87	
	ANDREWS	6	54	895	844	55	8,946	7,877	1,068	
	ANGELINA	5	55	737	696	44	13,211	12,413	798	
	ARANSAS	3	89	1,287	1,211	81	15,644	14,824	819	
	ARCHER	7	4	70	66	4	781	684	96	
	ATASCOSA	3	58	903	860	46	5,705	5,081	624	
	AUSTIN	4	21	288	272	17	4,166	3,936	230	
	BANDERA	5	0	0	0	0	0	0	0	
	BAYLOR	7	0	0	0	0	0	0	0	
	BEE	3	9	126	119	8	1,782	1,681	101	
	BELL	5	1,846	29,817	28,280	1,644	269,749	237,123	32,625	
	BLANCO	5	2	33	31	2	257	228	29	
	BORDEN	7	19	271	256	16	9,220	8,090	1,130	
	BOSQUE	5	2	32	31	2	292	257	35	
	BRAZOS	4	727	9,955	9,411	582	144,226	136,257	7,969	
	BREWSTER	5	7	116	109	7	1,013	891	122	
	BRISCOE	8	7	130	122	9	2,256	1,985	271	
	BROOKS	2	0	0	0	0	0	0	0	
	BROWN	5	57	921	873	51	8,329	7,322	1,007	
	BURLESON	4	35	479	453	28	6,943	6,560	383	
	BURNET	5	168	2,790	2,622	180	21,558	19,123	2,435	
	CALHOUN	3	64	896	845	54	12,673	11,956	717	
	CALLAHAN	6	7	117	110	7	1,168	1,032	136	
	CAMERON	2	1,012	15,103	14,189	978	143,069	135,308	7,761	
	CHEROKEE	5	18	241	228	14	4,324	4,062	262	
	CHILDRESS	7	0	0	0	0	0	0	0	
	CLAY	7	1	18	17	1	195	171	24	
	COKE	6	1	17	16	1	145	127	18	
	COLEMAN	5	1	17	16	1	167	148	19	
	COLORADO	4	15	205	194	12	2,976	2,811	164	
	COMANCHE	5	1	16	15	1	146	128	18	
	CONCHO	5	1	17	16	1	145	127	17	
	COOKE	6	37	637	597	42	5,491	4,866	625	
	CORYELL	5	206	3,327	3,156	183	30,102	26,461	3,641	
	COTTLE	7	0	0	0	0	0	0	0	
	CRANE	5	66	63	63	4	664	584	80	
	CROCKETT	5	19	315	297	19	2,750	2,419	332	
	CROSBY	7	8	114	108	7	3,882	3,406	476	
	CULBERSON	6	1	15	14	1	163	141	21	
	DAWSON	7	6	167	158	10	5,530	4,829	701	
	DE WITT	3	4	56	53	3	792	747	45	
	DELTA	6	4	69	65	5	592	525	67	
	DICKENS	7	0	0	0	0	0	0	0	
	DIMMIT	3	5	79	75	4	428	388	40	
	DUVAL	3	0	0	0	0	0	0	0	
	EASTLAND	6	0	0	0	0	0	0	0	
	ECTOR	6	581	9,633	9,085	587	96,250	84,755	11,495	
	EDWARDS	5	0	0	0	0	0	0	0	
	ERATH	6	46	766	724	46	7,674	6,780	895	
	FALLS	5	6	97	92	5	877	771	106	
	FANNIN	6	18	310	291	21	2,671	2,367	304	
	FAYETTE	4	4	55	52	3	794	750	44	
	FISHER	6	0	0	0	0	0	0	0	
	FOARD	7	0	0	0	0	0	0	0	
FRANKLIN	6	0	0	0	0	0	0	0		
FREESTONE	5	10	162	153	9	1,461	1,285	177		
FRIO	3	31	483	460	25	3,049	2,716	333		

Table 9: 2012 Annual Electricity Savings from Implementation of the 2006 IECC for Single-family Residences Using 2008 Base Year (Continued)

2012 Summary TRY 2008									
	County	Climate Zone	No. of Projected Units (2012)	Precode Total Annual Elec. Use (MWh/yr)	Code-compliant Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	Precode Total NG Use (Therm/yr)	Code-compliant Total NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
ERCOT	GILLESPIE	5	34	565	531	36	4,363	3,870	493
	GLASSCOCK	6	0	0	0	0	0	0	0
	GOLIAD	3	0	0	0	0	0	0	0
	GONZALES	4	1	16	15	1	104	93	11
	GRAYSON	6	71	1,222	1,146	81	10,536	9,337	1,200
	GRIMES	4	25	342	324	20	4,960	4,686	274
	HALL	8	0	0	0	0	0	0	0
	HAMILTON	5	2	32	31	2	292	257	35
	HARDEMAN	7	0	0	0	0	0	0	0
	HASKELL	6	2	33	31	2	334	295	39
	HIDALGO	2	2,866	42,772	40,182	2,771	405,174	383,194	21,979
	HILL	5	2	32	31	2	292	257	35
	HOPKINS	6	9	155	145	10	1,332	1,181	152
	HOUSTON	5	5	67	63	4	1,201	1,128	73
	HOWARD	6	15	249	235	15	2,485	2,188	297
	HUDSPETH	6	0	0	0	0	0	0	0
	IRION	5	0	0	0	0	0	0	0
	JACK	6	10	167	157	10	1,668	1,474	194
	JACKSON	3	10	140	132	8	1,980	1,868	112
	JEFF DAVIS	6	0	0	0	0	0	0	0
	JIM HOGG	2	0	0	0	0	0	0	0
	JIM WELLS	3	35	506	476	32	6,152	5,830	322
	JONES	6	0	0	0	0	0	0	0
	KARNES	3	61	944	899	48	6,060	5,410	650
	KENDALL	5	271	4,224	4,022	217	26,595	23,677	2,918
	KENEDY	2	0	0	0	0	0	0	0
	KENT	7	0	0	0	0	0	0	0
	KERR	5	46	764	718	49	5,903	5,236	667
	KIMBLE	5	0	0	0	0	0	0	0
	KING	7	0	0	0	0	0	0	0
	KINNEY	4	0	0	0	0	0	0	0
	KLEBERG	2	19	273	257	17	3,105	2,930	175
	KNOX	7	0	0	0	0	0	0	0
	LA SALLE	3	5	79	75	4	428	388	40
	LAMAR	6	11	163	154	9	2,826	2,659	167
	LAMPASAS	5	7	113	107	6	1,023	899	124
	LAVACA	4	17	237	223	14	3,152	2,961	191
	LEE	4	47	781	734	50	6,047	5,360	687
	LEON	5	0	0	0	0	0	0	0
	LIMESTONE	5	1	16	15	1	146	128	18
	LIVE OAK	3	13	188	177	12	2,285	2,165	120
	LLANO	5	37	615	577	40	4,748	4,212	536
	LOVING	6	0	0	0	0	0	0	0
	MADISON	4	34	466	440	27	6,745	6,372	373
	MARTIN	6	4	66	63	4	663	584	79
	MASON	5	3	50	47	3	385	341	43
	MATAGORDA	3	71	994	938	60	14,059	13,263	796
	MAVERICK	3	75	1,180	1,125	59	6,415	5,818	597
	MCCULLOCH	5	0	0	0	0	0	0	0
	MCLENNAN	5	489	7,899	7,491	436	71,456	62,813	8,642
MCMULLEN	3	0	0	0	0	0	0	0	
MEDINA	4	14	221	209	12	1,457	1,305	152	
MENARD	5	0	0	0	0	0	0	0	
MIDLAND	6	599	9,832	9,366	605	99,231	87,381	11,850	
MILAM	4	3	46	43	2	299	268	31	
MILLS	5	0	0	0	0	0	0	0	
MITCHELL	6	4	67	63	4	667	590	78	
MONTAGUE	6	10	172	161	11	1,484	1,315	169	
MOTLEY	7	0	0	0	0	0	0	0	
NACOGDOCHES	5	38	509	481	31	9,128	8,576	552	
NAVARRO	5	74	1,195	1,134	66	10,813	9,505	1,308	
NOLAN	6	1	17	16	1	167	147	19	
PALO PINTO	6	9	150	142	9	1,501	1,326	175	
PECOS	5	6	99	94	6	869	764	105	
PRESIDIO	5	3	50	47	3	434	382	52	
RAINS	6	2	34	32	2	296	262	34	
REAGAN	5	2	33	31	2	332	292	40	
REAL	5	0	0	0	0	0	0	0	
RED RIVER	6	7	104	98	6	1,798	1,692	106	
REEVES	6	2	33	31	2	331	292	40	
REFUGIO	3	10	140	132	8	1,980	1,868	112	
ROBERTSON	4	22	301	285	18	4,364	4,123	241	
RUNNELS	5	0	0	0	0	0	0	0	
SAN SABA	5	0	0	0	0	0	0	0	
SCHLEICHER	5	5	83	78	5	724	636	87	
SCURRY	7	51	726	687	42	24,748	21,714	3,033	
SHACKELFORD	6	0	0	0	0	0	0	0	
SOMERVELL	5	6	103	97	7	892	790	102	
STARR	2	2	30	28	2	283	267	15	
STEPHENS	6	3	50	47	3	500	442	58	
STERLING	6	0	0	0	0	0	0	0	
STONEWALL	7	0	0	0	0	0	0	0	
SUTTON	5	0	0	0	0	0	0	0	
TAYLOR	6	234	3,898	3,681	233	39,038	34,488	4,551	
TERRELL	5	0	0	0	0	0	0	0	
THROCKMORTON	6	0	0	0	0	0	0	0	
TITUS	6	13	192	182	11	3,340	3,142	198	
TOM GREEN	5	229	3,792	3,574	233	33,149	29,150	3,999	
UPTON	5	7	116	110	7	1,162	1,021	141	
UVALDE	4	21	331	314	18	2,185	1,957	228	
VAL VERDE	4	29	457	433	25	3,018	2,703	315	
VAN ZANDT	6	5	86	81	6	740	656	84	
WARD	6	10	166	156	10	1,657	1,459	198	
WASHINGTON	4	35	479	453	28	6,943	6,560	384	
WEBB	3	750	11,797	11,245	590	64,150	58,176	5,974	
WHARTON	3	76	1,064	1,004	64	15,049	14,197	852	
WICHITA	7	118	2,073	1,954	127	23,031	20,192	2,839	
WILBARGER	7	0	0	0	0	0	0	0	
WILLACY	2	37	552	519	36	5,231	4,947	284	
WINKLER	6	2	33	31	2	331	292	40	
WISE	6	29	499	468	33	4,294	3,804	490	
YOUNG	6	29	483	456	29	4,838	4,274	564	
ZAPATA	2	0	0	0	0	0	0	0	
ZAVALA	3	7	110	105	6	599	543	56	
	TOTAL		79,841			75,591			1,086,928

Table 5: Allocation of CM Zones for each of Applicable ERCOT Counties<sup>20</sup><sup>20</sup> Of a total of 202 counties, 138 counties are not included in this table since the corresponding providers could not be assigned for these 138 counties.

County	Plant	CM Zones Percentage			
		H	N	W	S
Andrews	Fullerton	0.10	0.58	99.31	0.01
Atascosa	San Miguel	11.04	0.74	0.04	88.18
Bastrop	Bastrop Energy Center	11.04	0.74	0.04	88.18
	Lost Pines 1 Power Project				
	Sim Gideon 1				
	Sim Gideon 2				
Bexar	Sim Gideon 3	11.04	0.74	0.04	88.18
	Arthur Von Rosenberg				
	Covel Gardens				
	J K Spruce				
	J K Spruce 2				
	J T Deely 1				
	J T Deely 2				
	Leon Creek				
	O W Sommers 1				
	O W Sommers 2				
	University of Texas at San Antonio				
Bosque	V H Braung 1	13.35	81.87	3.95	0.84
	V H Braung 2				
	V H Braung 3				
	V H Braung 6				
Brazoria	W B Tuttle	99.06	0.01	0.00	0.93
	Bosque County Peaking				
	BASF Freeport Works				
	Chocolate Bayou Plant				
	Chocolate Bayou Works				
	Dow Chemical Texas Operation				
	Freeport Energy Center (expansion)				
Brazos	Oyster Creek Unit VIII	13.09	72.93	3.52	10.45
	Sweeney Cogen Facility				
	Bryan 3				
	Bryan 4				
	Bryan 5				
	Bryan 6				
	Bryan 7				
Caldwell	Dansby 1	11.04	0.74	0.04	88.18
	Dansby 2				
	Dansby 3				
Cameron	Point Comfort Operations	11.04	0.74	0.04	88.18
	Seadrift Coke LP				
	Union Carbide Seadrift Cogen				
Chambers	La Palma 4	11.04	0.74	0.04	88.18
	La Palma 5				
	La Palma 6				
	La Palma 7				
	Silas Ray				
Cherokee	Baytown Energy Center	99.06	0.01	0.00	0.93
	Cedar Bayou 1				
	Cedar Bayou 2				
	Enterprise Products Operating				
Coke	Stryker Creek 1	13.35	81.87	3.95	0.84
	Stryker Creek 2				
	Stryker Creek 3				
Collin	Jameson Gas Processing Plant	0.00	0.00	0.00	0.00
	Ray Olinger 2				
	Ray Olinger 3				
	Ray Olinger 4				
	Ray Olinger 5				
Dallas	University of Texas at Dallas	13.35	81.87	3.95	0.84
	C E Newman				
	Lake Hubbard 1				
	Lake Hubbard 2				
	Mountain Creek				
Denton	State Farm Insurance Support Center Central	13.35	81.87	3.95	0.84
	Spencer 4				
Ector	Spencer 5	0.97	0.60	91.36	7.07
	Odessa Ector Generating Station				
	Quail Run Energy Center				
	Quail Run Energy Center				
Ellis	Quail Run Energy Center	13.35	81.87	3.95	0.84
	Ennis Tractebel Power LP				
Fannin	Midlothian Energy Facility	13.35	81.87	3.95	0.84
	Valley				
Fayette	Fayette Power Project	11.89	30.55	1.48	56.09
	Winchester Power Park				
Fort Bend	Brazos Valley Generating Facility	99.06	0.01	0.00	0.93
	W A Parish 1				
	W A Parish 2				
	W A Parish 3				
	W A Parish 4				
	W A Parish 5				
	W A Parish 7 (Upgraded)				
	W A Parish 8				
Freestone	W A Parish GT1	13.35	81.87	3.95	0.84
	Big Brown 1 (Upgrade)				
	Big Brown 2				
Frio	Freestone Power Generation LP	0.10	0.58	99.31	0.01
	Pearsall 1				
	Pearsall 2				
Galveston	Pearsall 3	99.06	0.01	0.00	0.93
	Green Power 2				
	P H Robinson				
	Power Station 4				
	S&L Cogeneration				
	Texas City Plant Union Carbide				
	Texas City Power Plant				
Goliad	Valero Refining Texas City	0.00	0.00	0.00	0.00
Grimes	Coletto Creek	0.00	0.00	0.00	0.00
Guadalupe	Gibbons Creek	0.00	0.00	0.00	0.00
	Guadalupe Generating Station	11.04	0.74	0.04	88.18
	Rio Nueces Power Project				

Table 10: Allocation of CM Zones for each of Applicable ERCOT Counties (Continued)<sup>21</sup><sup>21</sup> Of a total of 202 counties, 138 counties are not included in this table since the corresponding providers could not be assigned for these 138 counties.

County	Plant	CM Zones Percentage			
		H	N	W	S
Harris	AES Deepwater				
	Altura Cogen				
	Bayou Cogen Plant				
	Cedar Bayou 4				
	Channel Energy Center				
	Channelview Cogeneration Plant				
	Clear Lake Cogeneration Ltd				
	Deepwater				
	Deer Creek Energy Center				
	Deer Park Energy Center				
	Exelon LaPorte Generating Station				
	ExxonMobil Baytown Refinery				
	ExxonMobil Baytown Turbine				
	Greens Bayou 5				
	Greens Bayou Others				
	Hiram Clarke				
	Houston Chemical Complex Battleground	99.06	0.01	0.00	0.93
	Pasadena				
	Pasadena Cogeneration				
	Rice University				
	Sam Bertron 1				
	Sam Bertron 2				
	Sam Bertron 3				
	Sam Bertron 4				
	Sam Bertron Others				
	San Jacinto Steam Electric Station				
	Shell Deer Park				
	TH Wharton				
	Texas Medical Center				
	Texas Petrochemicals				
	Valero Refining Texas Houston				
	Webster				
	Westhollow Technology Center				
Hays	Hays Energy Project	11.04	0.74	0.04	88.18
Henderson	Southwest Texas State University	13.35	81.87	3.95	0.84
Hidalgo	Trinidad				
	Frontiera Energy Center				
	Hidalgo Energy Center				
	J/L Bates 1	11.04	0.74	0.04	88.18
Hood	J/L Bates 2				
	Magic Valley Generating Station				
	DeCordova Steam Electric Station 1	13.35	81.87	3.95	0.84
	DeCordova Steam Electric Station Cfs				
Howard	Wolf Hollow L.P.				
	Big Spring Carbon Plant	0.20	0.59	98.34	0.87
Hunt	CR Wing Cogen Plant				
	Engine Plant				
	Greenville	11.08	2.24	0.11	86.57
Jack	Powerlane Plant				
	Jack County Project	13.35	81.87	3.95	0.84
Johnson	Jack Energy Facility	13.35	81.87	3.95	0.84
Kaufman	Johnson County	13.35	81.87	3.95	0.84
Lamar	Forney Energy Center	13.35	81.87	3.95	0.84
	Lamar Power Project	13.35	81.87	3.95	0.84
Limestone	Paris Generating Station				
	Limestone 1	0.00	0.00	0.00	0.00
Llano	Limestone 2 (Upgraded)	11.04	0.74	0.04	88.18
McLennan	Thomas C Ferguson				
	Baylor University Cogen				
	Lake Creek	13.35	81.87	3.95	0.84
	Tradinghouse 1				
Miami	Tradinghouse 2				
	Sandow 5	11.04	0.74	0.04	88.18
	Sandow No 4				
Michell	Sandow Station	0.10	0.58	99.31	0.01
Nolan	Morgan Creek	0.10	0.58	99.31	0.01
Nueces	TXU Sweetwater Generating Plant				
	Barney M. Davis 1				
	Barney M. Davis 2				
	Barney M. Davis Power Plant (repowering)	11.04	0.74	0.04	88.18
	Celanese Engineering Resin				
	Corpus Christi				
	Corpus Christi Energy Center				
	Corpus Refinery				
Palo Pinto	Nueces Bay Power Plant (repowering)				
	Valero Refinery Corpus Christi East				
	Valero Refinery Corpus Christi West				
Parker	RW Miller 1	13.35	81.87	3.95	0.84
	RW Miller 2				
	RW Miller 3				
	RW Miller Others				
Pecos	North Texas	13.35	81.87	3.95	0.84
Reagan	Weatherford	0.10	0.58	99.31	0.01
Robertson	Yates Gas Plant	0.10	0.58	99.31	0.01
	MdMf Plant				
	Oak Grove 1				
	Oak Grove 2	11.34	11.28	0.55	76.83
Rusk	Twin Oaks Power One 1				
	Twin Oaks Power One 2				
San Patricio	Martin Lake	0.00	0.00	0.00	0.00
Scurry	Gregory Power Facility	11.04	0.74	0.04	88.18
	Ingliside Cogeneration				
Tarrant	EG178 Facility	0.10	0.58	99.31	0.01
Titus	Eagle Mountain	13.35	81.87	3.95	0.84
	Handley				
	Monticello	0.00	0.00	0.00	0.00

Table 10: Allocation of CM Zones for each of Applicable ERCOT Counties (Continued)<sup>22</sup><sup>22</sup> Of a total of 202 counties, 138 counties are not included in this table since the corresponding providers could not be assigned for these 138 counties.



County	Plant	CM Zones Percentage			
		H	N	W	S
Travis	Central Utility Plant	11.04	0.74	0.04	88.18
	Decker Creek 1				
	Decker Creek 2				
	Decker Creek GT (1-4)				
	Hal C Weaver Power Plant				
	Holly Street 3				
	Holly Street 4				
	Mueller Energy Center				
Upton	Sand Hill	0.10	0.58	99.31	0.01
	Benedum Plant				
Victoria	Sam Rayburn	11.04	0.74	0.04	88.18
	Victoria (refurbish)				
	Victoria Texas Plant				
Ward	Permian Basin 5	0.10	0.58	99.31	0.01
	Permian Basin 6				
	Permian Basin Others				
Webb	Laredo 1	11.04	0.74	0.04	88.18
	Laredo 2				
	Laredo 3				
	Laredo Energy Center (refurbish)				
Wharton	Colorado Bend Energy Center	11.04	0.74	0.04	88.18
	Colorado Bend Energy Center				
	Colorado Bend Energy Center				
	New gulf Cogen				
Wichita	PFO Industries Works 4	0.10	0.58	99.31	0.01
	Signal Hill Wichita Falls Power LP				
Wilbarger	Oklahoma	13.35	81.87	3.95	0.84
Wise	Bridgeport Gas Processing Plant	13.35	81.87	3.95	0.84
Young	Wise County Power LP	13.35	81.87	3.95	0.84
	Graham 1				
	Graham 2				

Table 6: 2012 Totalized Annual Electricity Savings from the 2006 IECC by CM Zones for Single-family Residences Using 2008 Base Year

CM Zones	Total Electricity Savings by CM Zones (MWh) 2012-TRY 2008
<b>H</b>	24,698.00
<b>N</b>	19,425.06
<b>W</b>	1,765.47
<b>S</b>	13,902.28
<b>Total</b>	59,790.81

Table 7: 2012 Annual NO<sub>x</sub> Reductions from the 2006 IECC by CM Zones for Single-family Residences by County Using 2010 eGRID

Area	County	H	NOx Reductions (lbs)	N	NOx Reductions (lbs)	W	NOx Reductions (lbs/year)	S	NOx Reductions (lbs)	Total NOx Reductions (lbs)	Total NOx Reductions (Tons)
Houston- Galveston Area	Brazoria	0.0562032	1388.1066228	0.0000071	0.1385114	0.0000003	0.0006081	0.0005265	7.3201351	1395.5658773	0.6977829
	Chambers	0.0204500	505.0742533	0.0000026	0.0503985	0.0000001	0.0002212	0.0001916	2.6634926	507.7883658	0.2538942
	Fort Bend	0.0313463	774.1915047	0.0000040	0.0772522	0.0000002	0.0003391	0.0002937	4.0826737	778.3517698	0.3891759
	Galveston	0.0226620	559.7052534	0.0000029	0.0558498	0.0000001	0.0002452	0.0002123	2.9515874	562.7129359	0.2813565
	Harris	0.1486911	3672.3734775	0.0000189	0.3664455	0.0000009	0.0016087	0.0013930	19.3661420	3692.1076738	1.8460538
Dallas/ Fort Worth Area	Collin	0.0012932	31.9386656	0.0079329	154.0975872	0.0003832	0.6764834	0.0000809	1.1251766	187.8379127	0.0939190
	Dallas	0.0024826	61.3154645	0.0152295	295.8346873	0.0007356	1.2987047	0.0001554	2.1601004	360.6089569	0.1803045
	Denton	0.0001267	3.1283363	0.0007770	15.0935883	0.0000375	0.0662604	0.0000079	0.1102091	18.3983940	0.0091992
	Tarrant	0.0004742	11.7113641	0.0029089	56.5049578	0.0001405	0.2480549	0.0000297	0.4125831	68.8769599	0.0344385
	Ellis	0.0029920	73.8962260	0.0183544	356.5343113	0.0008865	1.5651741	0.0001873	2.6303117	434.5990231	0.2172995
	Johnson	0.0007256	17.9208433	0.0044512	86.4644363	0.0002150	0.3795761	0.0000454	0.6313386	105.3961942	0.0526981
	Kaufman	0.0059718	147.4927165	0.0366343	711.6224597	0.0017695	3.1239996	0.0003738	5.1960639	867.4352397	0.4337176
	Parker	0.0000012	0.0303667	0.0000075	0.1465132	0.0000004	0.0006432	0.0000001	0.0010698	0.1785928	0.0000893
	Henderson	0.0006908	17.0607919	0.0042376	82.3148624	0.0002047	0.3613596	0.0000432	0.6010396	100.3380535	0.0501690
	Hood	0.0050771	125.3941104	0.0311454	605.0011648	0.0015044	2.6559356	0.0003178	4.4175456	737.4687564	0.3687344
	Hunt	0.0088463	218.4868086	0.0047066	91.4266898	0.0002273	0.4013602	0.0652823	907.5727097	1217.8875683	0.6089438
San Antonio Area	Bexar	0.0138906	343.0701737	0.0009368	18.1976623	0.0000452	0.0798871	0.1109355	1542.2568925	1903.6046156	0.9518023
Austin Area	Guadalupe	0.0032029	79.1049593	0.0002160	4.1960084	0.0000104	0.0184203	0.0255795	355.6128691	438.9322572	0.2194661
	Bastrop	0.0033782	83.4353783	0.0002278	4.4257092	0.0000110	0.0194287	0.0269798	375.0800771	462.9605933	0.2314803
	Hays	0.0008331	20.5766171	0.0000562	1.0914570	0.0000027	0.0047915	0.0066537	92.5012782	114.1741438	0.0570871
	Travis	0.0051785	127.8994665	0.0003493	6.7842426	0.0000169	0.0297826	0.0413577	574.9664322	709.6799240	0.3548400
Corpus Christi Area	Rusk	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Nueces	0.0128578	317.5614250	0.0008672	16.8445875	0.0000419	0.0739472	0.1026870	1427.5834336	1762.0633933	0.8810317
	San Patricio	0.0015100	37.2928358	0.0001018	1.9781447	0.0000049	0.0086840	0.0120591	167.6483046	206.9279690	0.1034640
Victoria Area	Victoria	0.0021192	52.3389111	0.0001429	2.7762420	0.0000069	0.0121876	0.0169244	235.2872752	290.4146159	0.1452073
Other ERCOT counties	Andrew s	0.0000037	0.0924754	0.0000230	0.4461749	0.0039003	6.8858355	0.0000002	0.0032578	7.4277436	0.0037139
	Bosque	0.0022204	54.8400360	0.0136212	264.5920572	0.0006579	1.1615506	0.0001390	1.9319756	322.5256194	0.1612628
	Brazos	0.0024089	59.4944547	0.0112305	218.1534272	0.0005425	0.9576865	0.0047829	66.4933338	345.0989022	0.1725495
	Callhoun	0.0009466	23.3787031	0.0000638	1.2400896	0.0000031	0.0054440	0.0075598	105.0979328	129.7221694	0.0648611
	Cameron	0.0063536	156.9219726	0.0004285	8.3236996	0.0000207	0.0365408	0.0507425	705.4358333	870.7180463	0.4353590
	Cherokee	0.0027392	67.6516587	0.0168033	326.4055401	0.0008116	1.4329098	0.0001714	2.3833200	397.8734286	0.1989367
	Coke	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Ector	0.0019215	47.4574158	0.0006604	12.8274333	0.0911346	160.8958683	0.0146527	203.7057075	424.8864249	0.2124432
	Fannin	0.0000041	0.1001483	0.0000249	0.4831953	0.0000012	0.0021212	0.0000003	0.0035282	0.5889930	0.0002945
	Fayette	0.0051867	128.1011754	0.0103217	200.4991620	0.0004986	0.8801848	0.0283993	394.8150885	724.2956107	0.3621478
	Freestone	0.0047643	117.6696433	0.0292268	567.7321765	0.0014117	2.4923259	0.0002982	4.1454181	692.0395638	0.3460198
	Frio	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Grimes	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Hidalgo	0.0053716	132.6671761	0.0003623	7.0371389	0.0000175	0.0308928	0.0428994	596.3994610	736.1346687	0.3680673
	Howard	0.0002411	5.9551271	0.0007641	14.8421083	0.1283942	226.6766024	0.0009490	13.1931389	260.6669766	0.1303335
	Jack	0.0030783	76.0281857	0.0188839	366.8205845	0.0009121	1.6103305	0.0001927	2.6784191	447.1375198	0.2235688
	Lamar	0.0040001	98.7955048	0.0245388	476.6682842	0.0011853	2.0925584	0.0002504	3.4804956	581.0368430	0.2905184
	Limestone	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Llano	0.0040314	99.5686917	0.0002719	5.2814776	0.0000131	0.0231855	0.0321966	447.6066788	552.4800336	0.2762400
	McLennan	0.0056576	139.7319595	0.0347066	674.1783801	0.0016764	2.9596213	0.0003541	4.9226579	821.7926188	0.4108963
	Milam	0.0012686	31.3320378	0.0000856	1.6619627	0.0000041	0.0072960	0.0101316	140.8517993	173.8530958	0.0869265
	Mitchell	0.0000311	0.7688184	0.0001910	3.7093929	0.0324260	57.2472142	0.0000019	0.0270849	61.7525105	0.0308763
	Nolan	0.0000293	0.7225487	0.0001795	3.4861508	0.0304745	53.8019097	0.0000018	0.0254549	58.0360641	0.0290180
	Palo Pinto	0.0036129	89.2323584	0.0221635	430.5280413	0.0010705	1.8900042	0.0002261	3.1435927	524.7939966	0.2623970
	Pecos	0.0000020	0.0486536	0.0000121	0.2347435	0.0020520	3.6228067	0.0000001	0.0017140	3.9079178	0.0019540
	Robertson	0.0039506	97.5712788	0.0055755	108.3038979	0.0002693	0.4754506	0.0246170	342.2318278	548.5824550	0.2742912
	Titus	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Upton	0.0000025	0.0628179	0.0000156	0.3038035	0.0026494	4.6775003	0.0000002	0.0022130	5.0456148	0.0025228
	Ward	0.0001995	4.9277247	0.0012239	23.7752727	0.2078335	366.9247636	0.0000125	0.1736002	395.8013612	0.1979007
	Webb	0.0042017	103.7742332	0.0002834	5.5045544	0.0000137	0.0241648	0.0335565	466.5125059	575.8154584	0.2879077
	Wharton	0.0021095	52.1007566	0.0001423	2.7636094	0.0000069	0.0121322	0.0168474	234.2166622	289.0931604	0.1445466
	Wichita	0.0000121	0.2991957	0.0000743	1.4435585	0.0126190	22.2784979	0.0000008	0.0105405	24.0317925	0.0120159
	Wilbarger	0.0179710	443.8479796	0.1102430	2141.4765315	0.0053249	9.4010128	0.0011247	15.6364497	2610.3619737	1.3051810
	Wise	0.0010202	25.1964202	0.0062583	121.5676200	0.0003023	0.5336779	0.0000638	0.8876520	148.1853702	0.0740927
	Young	0.0071054	175.4892037	0.0435880	846.6988351	0.0021054	3.7169849	0.0004447	6.1823603	1032.0883840	0.5160442
<b>Total</b>		<b>0.4414501</b>	<b>10902.93493</b>	<b>0.4812863</b>	<b>9349.012953</b>	<b>0.5345786</b>	<b>943.7847773</b>	<b>0.6829349</b>	<b>9494.351446</b>	<b>30690.0841035</b>	<b>15.3450421</b>
<b>Energy Savings by PCA (MWh)</b>											
			24,698.00		19,425.06		1,765.47		13,902.28		

#### 4.1.4 2012 Results for New Multi-family Residential Construction

This section provides potential electricity and natural gas reductions and associated emissions reductions from the implementation of the 2006 IECC for new multi-family residences in all the counties in ERCOT region as well as the 41 non-attainment and affected counties. To calculate the NOx emissions reductions from the implementation of the 2006 IECC for multi-family residences, new construction activity was determined by county. Energy savings attributable to the 2006 IECC was then calculated using the Laboratory's code-traceable, DOE-2.1e simulation, which was developed for the TERP. Next, these estimates were applied to the NAHB Builder's survey data to determine the appropriate number of housing types. In addition, the NOx reduction potential from the electricity reductions in each county was calculated using the US EPA's 2010 eGRID database<sup>23</sup>.

In Table 8, the 2012 and the 2006 IECC code-compliant building characteristics for multi-family are shown for each county. The 2006 IECC code-compliant characteristics are the minimum building code characteristics required by the 2006 IECC for each county for multi-family residences (i.e., Type A.2). In Table 8, the rows are sorted first by the US EPA's non-attainment and affected designation, and other ERCOT counties, alphabetically. The fifth, sixth, seventh, and eighth columns in Table 8 show the NAHB Builder's survey average glazing U-value, Solar Heat Gain Coefficient (SHGC), roof insulation and wall insulation, respectively. In columns ninth through twelfth, the corresponding values from the 2006 IECC code-compliant house are listed for each county (i.e., glazing U-value, SHGC, roof and wall insulation R-value).

The 2006 IECC SHGC is 0.4 for all non-attainment and affected counties as required by the 2006 IECC. All houses were assumed to have air conditioner efficiency equal to a SEER 13, and furnace efficiency (AFUE) of 0.80. The values shown in Table 8 represent the only changes that were made to the simulation to obtain the savings calculations. All other variables in the simulation remained the same for the 2012 and the 2006 IECC code-compliant simulation. In cases where the 2012 values were more efficient than the 2006 IECC code-compliant simulation, the 2012 values were used in both simulations, since this indicates that the prevailing practice is already above code.

In Table 9, the code-traceable simulation results for multi-family are shown for each county. In a similar fashion as Table 8, the tables are first divided into US EPA's non-attainment and affected classifications, followed by an alphabetical listing of other ERCOT counties. In the third column, the 2006 IECC climate zone is listed followed by the number of projected new housing units<sup>24</sup> in the fourth column. In the fifth column, the total simulated energy use is listed if all new construction had been built to pre-code specifications, and, in the sixth column, the total county-wide energy use for code-compliant construction is shown. 144 simulations were run for each county, which were then distributed according to the NAHB Builder's survey data to account for 1, 2 or 3 story, and 3 fuel options (i.e., central air conditioning with electric resistance heating, heat pump heating, or a natural gas-fired furnace).

In the seventh column of Table 9, the total annual electricity savings are shown for each county, respectively. In similar fashion as the 2011 report, a 7% transmission and distribution loss is used in the 2012 report, which represents a fixed 1.07 multiplier for the electricity use. In the eighth and ninth columns, the total annual pre-code and code-compliant natural gas use is shown for those residences that had natural gas-fired furnaces and domestic water heaters. Finally, in column in tenth, the total annual natural gas savings are shown for each county.

In Table 10, the annual electricity savings from Table 9 is assigned to CM Zones provider(s) in a similar fashion as the single-family residential assignments. The total electricity savings for each CM Zone, as shown in Table 10, are then entered into the bottom row of Table 11, the 2010 US EPA's eGRID database for Texas. eGRID then proportions each MWh of electricity savings according to the 2008 measured data from the power plants assigned to that CM Zones. For each county in which there is a power plant, the lbs-NOx/MWh are calculated and displayed as NOx reductions (lbs) in the column adjacent to the CM Zone column. In a similar fashion as the single-family residences, adding across the rows then totals the NOx reductions in each county from multiple CM Zones that have power plants in that county. Counties that do not show NOx reductions represent counties that do not have power plants in eGRID's database.

<sup>23</sup> This analysis assumes transmission and distribution losses of 7%. Counties were assigned to utility service districts as indicated in a fashion similar to the 2011 report.

<sup>24</sup> The number of projected new housing units uses the published values for the new housing units in 2012. A vacancy rate of 0% was assumed for 2010 calculations, based on information suggested by the Real Estate Center at Texas A&M University.

Table 8: 2012 and the 2006 IECC Code-compliant Building Characteristics used in the DOE-2 Simulations for Multi-family Residential Buildings

	COUNTY	Climate Zone	Division (East or West)	2012 Average				2006 IECC			
				Glazing U-value (Btu/hr-ft <sup>2</sup> -F)	SHGC	Roof Insulation (hr-ft <sup>2</sup> -F/Btu)	Wall Insulation (hr-ft <sup>2</sup> -F/Btu)	Glazing U-value (Btu/hr-ft <sup>2</sup> -F)	SHGC	Roof Insulation (hr-ft <sup>2</sup> -F/Btu)	Wall Insulation (hr-ft <sup>2</sup> -F/Btu)
Non-attainment	Brazoria	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Chambers	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Collin	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Dallas	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Denton	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	El Paso	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Fort Bend	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Galveston	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Hardin	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Harris	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Jefferson	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Liberty	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Montgomery	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Orange	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Tarrant	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Waller	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
Affected	Bastrop	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Bexar	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Caldwell	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Comal	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Ellis	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Griggs	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Guadalupe	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Harrison	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Hays	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Henderson	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Hood	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Hunt	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Johnson	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Kaufman	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Nueces	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Parker	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Rockwall	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Rusk	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	San Patricio	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Smith	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
ERCOT	Travis	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Upshur	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	Victoria	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Williamson	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	Wilson	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ANDERSON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ANDREWS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	ANGELINA	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ARKANSAS	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ARCHER	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	ATASCOSA	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	AUSTIN	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BANDERA	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BASTROP	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BAYLOR	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	BEE	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BELL	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BEXAR	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BLANCO	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	BORDEN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	BOSQUE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BRAZORIA	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BRAZOS	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BREWSTER	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	BROCK	4	West Texas	0.44	0.53	30.87	15.95	0.65	NR	38	13.00
	BROOKS	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BROWN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	BURLESON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	BURNET	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CALDWELL	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	CALHOUN	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	CALLAHAN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CAMERON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	CHAMBERS	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	CHEROKEE	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	CHILDRESS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CLAY	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	COKE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	COLEMAN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	COLLIN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	COLORADO	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	COMAL	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	COMANCHE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CONCHO	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	COOKE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CORYELL	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	COTTLE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CRANE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CROCKETT	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CROSBY	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	CULBERSON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	DALLAS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	DAWSON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	DE WITT	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	DELTA	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	DENTON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	DICKENS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	DIAMIT	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	DUVAL	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	EASTLAND	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	ECTOR	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	EDWARDS	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ELLIS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	ERATH	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	FALLS	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	FANNIN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	FAYETTE	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	FISHER	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	FOARD	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	FORT BEND	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	FRANKLIN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	FREESTONE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00

Table 13: 2012 and the 2006 IECC Code-compliant Building Characteristics used in the DOE-2 Simulations for Multi-family Residential Buildings (Continued)

	COUNTY	Climate Zone	Division (East or West)	2012 Average				2006 IECC			
				Glazing U-value (hr-ft <sup>2</sup> -F/Btu)	SHGC	Roof Insulation (hr-ft <sup>2</sup> -F/Btu)	Wall Insulation (hr-ft <sup>2</sup> -F/Btu)	Glazing U-value (hr-ft <sup>2</sup> -F/Btu)	SHGC	Roof Insulation (hr-ft <sup>2</sup> -F/Btu)	Wall Insulation (hr-ft <sup>2</sup> -F/Btu)
ERCOT	ERIO	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	GALVESTON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	GILLESPIE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	GLASSCOCK	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SQUAD	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	GONZALES	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	GRAYSON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	GRIMES	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	GUADALUPE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	HALL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HAMILTON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HARDERMAN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HARRIS	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	HASKELL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HAYS	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	HENDERSON	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HIDALGO	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	HILL	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	HOOD	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HOPKINS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HOUSTON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	HOWARD	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HUDSPETH	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	HUNT	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	IRION	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	JACK	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	JACKSON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	JEFF DAVIS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	JIM HOGG	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	JIM WELLS	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	JOHNSON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	JONES	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KARNES	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	KARFMAN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KENDALL	2	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KENDY	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	KENT	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KERR	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KIMBLE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KING	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	KINNEY	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	KLUBERG	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	KNOX	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	LA SALLE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	LAMAR	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	LAMPASAS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	LAVACA	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	LEE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	LEON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	LIMESTONE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	LIVE OAK	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	LLANO	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	LOVING	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MAUDSLON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MARTIN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MASON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MATAGORDA	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MAVERICK	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MCCLULLOCH	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MCLENNAN	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MCMLLEN	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MEDINA	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MENARD	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MIDLAND	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MILAM	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MILLS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MITCHELL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MONTAGUE	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	MONTGOMERY	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	MOTLEY	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	NACOGDOCHES	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	NAVARO	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	NOLAN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	NUECES	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	PALO PINTO	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	PARKER	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	PECOS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	PRESIDIO	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	RAINS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	REAGAN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	REAL	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	RED RIVER	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	REEVES	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	RELFUGIO	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ROBERTSON	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	ROCKWALL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	RUNNELS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	RUSK	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SAN PATRICK	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	SAN SABA	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SCHLEICHER	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SCURRY	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SHACKELFORD	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SMITH	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SOMERVELL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	STARR	2	East Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	STEPHENS	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	STERLING	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	STONEWALL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	SUTTON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	TARRANT	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	TAYLOR	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	TERRELL	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	THROCKMORTON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	TITUS	3	East Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	TOAM GREEN	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	TRAVIS	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	UPTON	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	UVALDE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	VAL VERDE	2	West Texas	0.44	0.53	30.87	15.95	0.75	0.40	30	13.00
	VAN ZANDT	3	West Texas	0.44	0.53	30.87	15.95	0.65	0.40	30	13.00
	VICTORIA	2	East Texas	0.44	0.						



Table 9: 2012 Annual Electricity and Natural Gas Savings from Implementation of the 2006 IECC for Multi-family Residences Buildings

2012 Summary TRY 2008									
	County	Climate Zone	No. of Projected Units (2012)	Precode Total Annual Elec. Use (MWh/yr)	Code-compliant Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	Precode Total NG Use (Therm/yr)	Code-compliant Total NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
Nonattainment County	BRAZORIA	3	438	19,725	19,042	730.79	95,025	94,895	130.62
	CHAMBERS	4	0	0	0	0.00	0	0	0.00
	COLLIN	6	3,504	174,683	166,192	9,085.60	1,026,361	952,811	73,549.66
	DALLAS	5	8,394	418,015	397,738	21,697.04	2,464,367	2,286,378	177,988.77
	DENTON	6	1,940	96,714	92,013	5,030.27	568,248	527,527	40,720.99
	EL PASO	6	1,179	53,042	50,892	2,514.65	362,191	330,702	31,488.99
	FORT BEND	4	208	9,369	9,044	347.72	45,126	45,053	73.37
	GALVESTON	3	183	8,241	7,956	305.33	39,702	39,648	54.57
	HARDIN	4	80	3,549	3,429	128.33	17,652	17,667	-15.42
	HARRIS	4	12,604	567,713	548,021	21,070.45	2,734,478	2,730,032	4,445.87
	JEFFERSON	4	456	20,234	19,549	733.15	100,616	100,524	92.05
	LIBERTY	4	4	180	174	6.72	867	866	0.86
	MONTGOMERY	4	1,162	52,339	50,524	1,942.55	252,100	251,690	409.88
	ORANGE	4	0	0	0	0.00	0	0	0.00
	TARRANT	5	2,732	136,052	129,452	7,061.75	802,079	744,149	57,930.11
	WALLER	4	63	2,838	2,739	105.32	13,668	13,646	22.22
Affected County	BASTROP	4	0	0	0	0.00	0	0	0.00
	BEXAR	4	2,822	130,377	125,204	5,535.85	641,869	608,867	33,001.99
	CALDWELL	4	4	192	183	9.62	0	0	0.00
	COMAL	4	26	1,201	1,154	51.00	5,914	5,610	304.06
	ELLIS	5	92	4,582	4,359	237.80	27,010	25,059	1,950.79
	GREGG	6	426	20,988	20,236	804.30	115,556	115,561	-5.01
	GUADALUPE	4	0	0	0	0.00	0	0	0.00
	HARRISON	6	6	295	284	11.13	1,634	1,634	0.01
	HAYS	5	1,901	91,230	86,965	4,573.59	485,321	451,551	33,770.04
	HENDERSON	5	16	786	758	29.59	4,363	4,364	-0.52
	HOOD	5	16	797	758	41.36	4,697	4,358	339.27
	HUNT	6	0	0	0	0.00	0	0	0.00
	JOHNSON	5	376	18,725	17,816	971.90	110,389	102,416	7,972.81
	KAUFMAN	6	0	0	0	0.00	0	0	0.00
	NUECES	3	223	10,322	9,921	429.62	44,290	44,247	43.08
	PARKER	6	96	4,786	4,553	248.92	28,119	26,104	2,015.06
	ROCKWALL	6	118	5,883	5,597	305.96	34,564	32,087	2,476.84
	RUSK	5	0	0	0	0.00	0	0	0.00
	SAN PATRICIO	3	0	0	0	0.00	0	0	0.00
	SMITH	5	125	6,140	5,924	231.16	34,089	34,093	-4.08
	TRAVIS	5	8,059	386,796	368,675	19,389.03	2,057,446	1,914,283	143,162.94
	UPSHUR	6	24	1,196	1,138	62.20	7,049	6,535	514.04
	VICTORIA	3	32	1,459	1,406	56.03	6,804	6,795	8.60
	WILLIAMSON	5	1,370	65,754	62,673	3,296.06	349,758	325,421	24,337.17
	WILSON	4	34	1,571	1,508	66.70	7,733	7,336	397.61
ERCOT	ANDERSON	5	0	0	0	0.00	0	0	0
	ANDREWS	6	0	0	0	0.00	0	0	0
	ANGELINA	5	2	90	87	3.28	480	479	1
	ARANSAS	3	0	0	0	0.00	0	0	0
	ARCHER	7	0	0	0	0.00	0	0	0
	ATASCOSA	3	8	370	355	15.62	1,845	1,744	101
	AUSTIN	4	0	0	0	0.00	0	0	0
	BANDERA	5	0	0	0	0.00	0	0	0
	BAYLOR	7	0	0	0	0.00	0	0	0
	BEE	3	0	0	0	0.00	0	0	0
	BELL	5	484	23,068	21,978	1,166.35	143,588	132,322	11,266
	BLANCO	5	26	1,248	1,189	62.55	6,638	6,176	462
	BORDEN	7	0	0	0	0.00	0	0	0
	BOSQUE	5	0	0	0	0.00	0	0	0
	BRAZOS	4	1,236	55,672	53,741	2,066.26	268,154	267,718	436
	BREWSTER	5	6	289	274	15.68	1,784	1,643	142
	BRISCOE	8	0	0	0	0.00	0	0	0
	BROOKS	2	0	0	0	0.00	0	0	0
	BROWN	5	0	0	0	0.00	0	0	0
	BURLESON	4	0	0	0	0.00	0	0	0
	BURNET	5	0	0	0	0.00	0	0	0
	CALHOUN	3	8	365	352	14.01	1,701	1,689	2
	CALLAHAN	6	8	387	367	21.47	2,605	2,392	212
	CAMERON	2	142	6,699	6,431	287.13	26,106	26,021	85
	CHEROKEE	5	2	90	87	3.28	480	479	1
	CHILDRESS	7	0	0	0	0.00	0	0	0
	CLAY	7	0	0	0	0.00	0	0	0
	COKE	6	0	0	0	0.00	0	0	0
	COLEMAN	5	0	0	0	0.00	0	0	0
	COLORADO	4	0	0	0	0.00	0	0	0
	COMANCHE	5	0	0	0	0.00	0	0	0
	CONCHO	5	0	0	0	0.00	0	0	0
	COOKE	6	0	0	0	0.00	0	0	0
	CORYELL	5	104	4,957	4,722	250.62	30,854	28,433	2,421
	COTTLE	7	0	0	0	0.00	0	0	0
	CRANE	5	0	0	0	0.00	0	0	0
	CROCKETT	5	0	0	0	0.00	0	0	0
	CROSBY	7	0	0	0	0.00	0	0	0
	CULBERSON	6	0	0	0	0.00	0	0	0
	DAWSON	7	0	0	0	0.00	0	0	0
	DE WITT	3	0	0	0	0.00	0	0	0
	DELTA	6	0	0	0	0.00	0	0	0
	DICKENS	7	0	0	0	0.00	0	0	0
	DIMMIT	3	0	0	0	0.00	0	0	0
	DUVAL	3	0	0	0	0.00	0	0	0
	EASTLAND	6	0	0	0	0.00	0	0	0
	ECTOR	6	428	20,721	19,643	1,152.98	137,424	125,869	11,555
	EDWARDS	5	0	0	0	0.00	0	0	0
	ERATH	6	8	387	367	21.47	2,605	2,392	212
	FALLS	5	0	0	0	0.00	0	0	0
	FANNIN	6	0	0	0	0.00	0	0	0
	FAYETTE	4	0	0	0	0.00	0	0	0
	FISHER	6	0	0	0	0.00	0	0	0
	FOARD	7	0	0	0	0.00	0	0	0
	FRANKLIN	6	0	0	0	0.00	0	0	0
	FREESTONE	5	0	0	0	0.00	0	0	0
	FRIO	3	0	0	0	0.00	0	0	0

Table 14: 2012 Annual Electricity and Natural Gas Savings from Implementation of the 2006 IECC for Multi-family Residences Buildings (Continued)

2012 Summary TRY 2008									
County	Climate Zone	No. of Projected Units (2012)	Precode Total Annual Elec. Use (MWh/yr)	Code-compliant Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	Precode Total NG Use (Therm/yr)	Code-compliant Total NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)	
ERCOT	GILLESPIE	5	0	0	0.00	0	0	0	
	GLASSCOCK	6	0	0	0.00	0	0	0	
	GOLIAD	3	0	0	0.00	0	0	0	
	GONZALES	4	0	0	0.00	0	0	0	
	GRAYSON	6	299	284	15.53	1,760	1,632	127	
	GRIMES	4	0	0	0.00	0	0	0	
	HALL	8	0	0	0.00	0	0	0	
	HAMILTON	5	0	0	0.00	0	0	0	
	HARDEMAN	7	0	0	0.00	0	0	0	
	HASKELL	6	0	0	0.00	0	0	0	
	HIDALGO	2	663	31,279	30,026	1,340.59	121,891	121,493	398
	HILL	5	0	0	0.00	0	0	0	
	HOPKINS	6	160	7,976	7,589	414.87	46,866	43,507	3,358
	HOUSTON	5	0	0	0.00	0	0	0	
	HOWARD	6	0	0	0.00	0	0	0	
	HUDSPETH	6	0	0	0.00	0	0	0	
	IRION	5	0	0	0.00	0	0	0	
	JACK	6	0	0	0.00	0	0	0	
	JACKSON	3	0	0	0.00	0	0	0	
	JEFF DAVIS	6	0	0	0.00	0	0	0	
	JIM HOGG	2	0	0	0.00	0	0	0	
	JIM WELLS	3	0	0	0.00	0	0	0	
	JONES	6	0	0	0.00	0	0	0	
	KARNES	3	0	0	0.00	0	0	0	
	KENDALL	5	0	0	0.00	0	0	0	
	KENEDY	2	0	0	0.00	0	0	0	
	KENT	7	0	0	0.00	0	0	0	
	KERR	5	0	0	0.00	0	0	0	
	KIMBLE	5	0	0	0.00	0	0	0	
	KING	7	0	0	0.00	0	0	0	
	KINNEY	4	0	0	0.00	0	0	0	
	KLEBERG	2	32	1,480	1,423	61.54	6,426	6,417	9
	KNOX	7	0	0	0.00	0	0	0	
	LA SALLE	3	102	4,721	4,539	196.51	20,259	20,238	20
	LAMAR	6	24	1,196	1,138	62.23	7,030	6,626	504
	LAMPASAS	5	0	0	0.00	0	0	0	
	LAVACA	4	0	0	0.00	0	0	0	
	LEE	4	16	768	732	38.47	4,086	3,801	285
	LEON	5	0	0	0.00	0	0	0	
	LIMESTONE	5	0	0	0.00	0	0	0	
	LIVE OAK	3	0	0	0.00	0	0	0	
	LLANO	5	10	480	457	24.06	2,553	2,375	178
	LOVING	6	0	0	0.00	0	0	0	
	MADISON	4	0	0	0.00	0	0	0	
	MARTIN	6	0	0	0.00	0	0	0	
	MASON	5	0	0	0.00	0	0	0	
	MATAGORDA	3	0	0	0.00	0	0	0	
	MAVERICK	3	4	185	178	7.71	794	794	1
	MCULLOCH	5	0	0	0.00	0	0	0	
	MCLENNAN	5	189	9,008	8,582	455.45	56,070	51,671	4,399
	MCNULLEN	3	0	0	0.00	0	0	0	
	MEDINA	4	12	554	532	23.54	2,729	2,589	140
	MENARD	5	0	0	0.00	0	0	0	
	MIDLAND	6	410	19,849	18,817	1,104.49	131,644	120,576	11,069
	MILAM	4	0	0	0.00	0	0	0	
	MILLS	5	0	0	0.00	0	0	0	
	MITCHELL	6	0	0	0.00	0	0	0	
	MONTAGUE	6	0	0	0.00	0	0	0	
	MOTLEY	7	0	0	0.00	0	0	0	
	NACOGDOCHE	5	206	9,272	8,956	337.46	49,491	49,380	101
	NAVARRO	5	42	2,002	1,907	101.21	12,460	11,482	978
	NOLAN	6	0	0	0.00	0	0	0	
	PALO PINTO	6	0	0	0.00	0	0	0	
	PECOS	5	0	0	0.00	0	0	0	
	PRESIDIO	5	2	96	91	5.23	595	548	47
	RAINS	6	0	0	0.00	0	0	0	
	REAGAN	5	0	0	0.00	0	0	0	
	REAL	5	0	0	0.00	0	0	0	
	RED RIVER	6	0	0	0.00	0	0	0	
	REEVES	6	0	0	0.00	0	0	0	
	REFUGIO	3	0	0	0.00	0	0	0	
	ROBERTSON	4	0	0	0.00	0	0	0	
	RUNNELS	5	0	0	0.00	0	0	0	
	SAN SABA	5	0	0	0.00	0	0	0	
	SCHLEICHER	5	0	0	0.00	0	0	0	
	SCURRY	7	40	1,992	1,882	118.26	16,768	15,181	1,587
	SHACKELFORD	6	0	0	0.00	0	0	0	
	SOMERVELL	5	0	0	0.00	0	0	0	
	STARR	2	0	0	0.00	0	0	0	
	STEPHENS	6	0	0	0.00	0	0	0	
	STERLING	6	0	0	0.00	0	0	0	
	STONEWALL	7	0	0	0.00	0	0	0	
	SUTTON	5	0	0	0.00	0	0	0	
	TAYLOR	6	206	9,969	9,452	552.90	67,068	61,599	5,469
	TERRELL	5	0	0	0.00	0	0	0	
	THROCKMORT	6	0	0	0.00	0	0	0	
	TITUS	6	2	100	95	5.19	586	544	42
	TOM GREEN	5	176	8,471	8,042	459.81	52,344	48,192	4,152
	UPTON	5	0	0	0.00	0	0	0	
	UVALDE	4	32	1,478	1,420	62.77	7,278	6,904	374
	VAL VERDE	4	48	2,218	2,130	94.16	10,918	10,356	561
	VAN ZANDT	6	0	0	0.00	0	0	0	
	WARD	6	0	0	0.00	0	0	0	
	WASHINGTON	4	0	0	0.00	0	0	0	
	WEBB	3	756	34,993	33,632	1,458.47	150,148	150,002	146
	WHARTON	3	0	0	0.00	0	0	0	
	WICHITA	7	146	7,542	7,121	450.85	54,439	49,636	4,803
	WILBARGER	7	0	0	0.00	0	0	0	
	WILLACY	2	0	0	0.00	0	0	0	
	WINKLER	6	0	0	0.00	0	0	0	
	WISE	6	4	199	190	10.37	1,172	1,088	84
	YOUNG	6	0	0	0.00	0	0	0	
	ZAPATA	2	0	0	0.00	0	0	0	
	ZAVALA	3	0	0	0.00	0	0	0	
	TOTAL		54,463		119,592			702,905	

Table 10: 2012 Totalized Annual Electricity Savings from the 2006 IECC by CM Zones for Multi-family Residences

<b>CM Zones</b>	<b>Total Electricity Savings by CM Zones (MWh) 2011-TRY 2008</b>
<b>H</b>	32,178.93
<b>N</b>	38,553.34
<b>W</b>	3,480.31
<b>S</b>	30,087.62
<b>Total</b>	104,300.20

Table 11: 2012 Annual NOx Reductions from the 2006 IECC by CM Zones for Multi-family Residences by County using 2010 eGRID

Area	County	H	NOx Reductions (lbs)	N	NOx Reductions (lbs)	W	NOx Reductions (lbs/year)	S	NOx Reductions (lbs)	Total NOx Reductions (lbs)	Total NOx Reductions (Tons)
Houston-Galveston Area	Brazoria	0.0562032	1808.5589327	0.0000071	0.2749066	0.0000003	0.0011987	0.0005265	15.8423982	1824.6774362	0.9123387
	Chambers	0.0204500	658.0593577	0.0000026	0.1000271	0.0000001	0.0004361	0.0001916	5.7643896	663.9242105	0.3319621
	Fort Bend	0.0313463	1008.6912190	0.0000040	0.1533242	0.0000002	0.0006685	0.0002937	8.8358127	1017.6810245	0.5088405
	Galveston	0.0226620	729.2378835	0.0000029	0.1108464	0.0000001	0.0004833	0.0002123	6.3878908	735.7371041	0.3678686
Dallas/ Fort Worth Area	Harris	0.1486911	4784.7216836	0.0000189	0.7272926	0.0000009	0.0031712	0.0013930	41.9126326	4827.3647800	2.4136824
	Collin	0.0012932	41.6127680	0.0079329	305.8409120	0.0003832	1.3335618	0.0000809	2.4351320	351.2223738	0.1756112
	Dallas	0.0024826	79.8876896	0.0152295	587.1496902	0.0007356	2.5601558	0.0001554	4.6749369	674.2724726	0.3371362
	Denton	0.0001267	4.0758976	0.0007770	29.9565807	0.0000375	0.1306200	0.0000079	0.2385169	34.4016153	0.0172008
	Tarrant	0.0004742	15.2586925	0.0029089	112.1466477	0.0001405	0.4889944	0.0000297	0.8929214	128.7872560	0.0643936
	Ellis	0.0029920	96.2791168	0.0183544	707.6215853	0.0008865	3.0854508	0.0001873	5.6341446	812.6202976	0.4063101
	Johnson	0.0007256	23.3489998	0.0044512	171.6078916	0.0002150	0.7482639	0.0000454	1.3663570	197.0715123	0.0985358
	Kaufman	0.0059718	192.1677093	0.0366343	1412.3729390	0.0017695	6.1583866	0.0003738	11.2454362	1621.9444711	0.8109722
	Parker	0.0000012	0.0395647	0.0000075	0.2907879	0.0000004	0.0012679	0.0000001	0.0023153	0.3339358	0.0001670
	Henderson	0.0006908	22.2284420	0.0042376	163.3721400	0.0002047	0.7123535	0.0000432	1.3007832	187.6137187	0.0938069
	Hood	0.0050771	163.3755180	0.0311454	1200.7592812	0.0015044	5.2356850	0.0003178	9.5605499	1378.9310341	0.6894655
	Hunt	0.008463	284.6656467	0.0047066	181.4565867	0.0002273	0.7912073	0.0652823	1964.1889150	2431.1023556	1.2155512
San Antonio Area	Bexar	0.0138906	446.9848476	0.0009368	36.1173055	0.0000452	0.1574827	0.1109355	3337.7864495	3821.0460853	1.9105230
	Guadalupe	0.0032029	103.0655560	0.0002160	8.3279113	0.0000104	0.0363123	0.0255795	769.6252300	881.0550096	0.4405275
Austin Area	Bastrop	0.003782	108.7076426	0.0002278	8.7838037	0.0000110	0.0383001	0.0269798	811.7565918	929.2863382	0.4646432
	Hays	0.0008331	26.8091976	0.0000562	2.1662389	0.0000027	0.0094455	0.0066537	200.1933106	229.1781926	0.1145891
	Travis	0.0051785	166.6397371	0.0003493	13.4648374	0.0000169	0.0587109	0.0413577	1244.3550590	1424.5183444	0.7122582
Corpus Christi Area	Rusk	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Nueces	0.0128578	413.7495943	0.0008672	33.4318279	0.0000419	0.1457732	0.1026870	3089.6076156	3536.9348109	1.7684674
	San Patricio	0.0015100	48.5886964	0.0001018	3.9260677	0.0000049	0.0171189	0.0120591	362.8281657	415.3600487	0.2076800
Victoria Area	Victoria	0.0021192	68.1927177	0.0001429	5.5100693	0.0000069	0.0240256	0.0169244	509.2139207	582.9401874	0.2914701
Other ERCOT counties	Andrew s	0.0000037	0.1204858	0.0000230	0.8855332	0.0039003	13.5741490	0.0000002	0.0070507	14.5872188	0.0072936
	Bosque	0.0022204	71.4508780	0.0136212	525.1417468	0.0006579	2.2897818	0.0001390	4.1812243	603.0636308	0.3015318
	Brazos	0.0024089	77.5151027	0.0112305	432.9739638	0.0005425	1.8879015	0.0047829	143.9063425	656.2833106	0.3281417
	Calhoun	0.0009466	30.4600250	0.0000638	2.4612334	0.0000031	0.0107317	0.0075598	227.4552687	260.3872588	0.1301936
	Cameron	0.0063536	204.4530519	0.0004285	16.5202319	0.0002007	0.0720334	0.0507425	1526.7198200	1747.7651372	0.8738826
	Cherokee	0.0027392	88.1430934	0.0168033	647.8243424	0.0008116	2.8247162	0.0001714	5.1580338	743.9501859	0.3719751
	Coke	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Ector	0.0019215	61.8320898	0.0006604	25.4588925	0.0911346	317.1763993	0.0146527	440.8643939	845.3317754	0.4226659
	Fannin	0.0000041	0.1304829	0.0000249	0.9590086	0.0000012	0.0041816	0.0000003	0.0076357	1.1013087	0.0005507
	Fayette	0.0051867	166.9025429	0.0103217	397.9351506	0.0004986	1.7351214	0.0283993	854.4675396	1421.0403544	0.7105202
	Freestone	0.0047643	153.3113386	0.0292268	1126.7906904	0.0014117	4.9131589	0.0002982	8.9716055	1293.9867934	0.6469934
	Frio	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Grimes	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Hidalgo	0.0053716	172.8515680	0.0003623	13.9667663	0.0000175	0.0608995	0.0428994	1290.7408934	1477.6201272	0.7388101
	Howard	0.0002411	7.7589128	0.0007641	29.4574627	0.1283942	446.8509310	0.0009490	28.5528828	512.6201894	0.2563101
	Jack	0.0030783	99.0568391	0.0188839	728.0369808	0.0009121	3.1744683	0.0001927	5.7966938	836.0649820	0.4180325
	Lamar	0.0040001	128.7202941	0.0245388	946.0541560	0.0011853	4.1250912	0.0002504	7.5325655	1086.4321067	0.5432161
	Limestone	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Llano	0.0040314	129.7276764	0.0002719	10.4822661	0.0000131	0.0457059	0.0321966	968.7202661	1108.9759146	0.5544880
	McLennan	0.0056576	182.0562479	0.0347066	1338.0568405	0.0016764	5.8343452	0.0003541	10.6537250	1536.6011587	0.7683006
	Milam	0.0012686	40.8223950	0.0000856	3.2985344	0.0000041	0.0143826	0.0101316	304.8345768	348.9698889	0.1744849
	Mitchell	0.0000311	1.0016906	0.0001910	7.3621148	0.0324260	112.8522780	0.0000019	0.0586178	121.2747012	0.0606374
	Nolan	0.0000293	0.9414060	0.0001795	6.9190412	0.0304745	106.0604984	0.0000018	0.0550900	113.9760356	0.0569880
	Palo Pinto	0.0036129	116.2605063	0.0221635	854.4785886	0.0010705	3.7257932	0.0002261	6.8034329	981.2683210	0.4906342
	Pecos	0.0000020	0.0633905	0.0000121	0.4659007	0.0020520	7.1416923	0.0000001	0.0037095	7.6746931	0.0038373
	Robertson	0.0039506	127.1252546	0.0055755	214.9531573	0.0002693	0.9372628	0.0246170	740.6656847	1083.6813594	0.5418407
	Titus	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Upton	0.0000025	0.0818452	0.0000156	0.6015366	0.0026494	9.2208254	0.0000002	0.0047895	9.9089967	0.0049545
	Ward	0.0001995	6.4203141	0.0012239	47.1873131	0.2078335	723.3242007	0.0000125	0.3757095	777.3073574	0.3886538
	Webb	0.0042017	135.2070608	0.0002834	10.9250118	0.0000137	0.0476365	0.0335565	1009.6366749	1155.8163839	0.5779082
	Wharton	0.0021095	67.8818811	0.0001423	5.4849972	0.0000069	0.0239163	0.0168474	506.8968764	580.2876711	0.2901438
	Wichita	0.0000121	0.3898209	0.0000743	2.8650627	0.0126190	43.9179316	0.0000008	0.0228119	47.1956271	0.0235978
	Wilbarger	0.0197710	578.2878744	0.1102430	4250.2361489	0.0053249	18.5323553	0.0011247	33.8407501	4880.8971280	2.4404486
	Wise	0.0010202	32.8283217	0.0062583	241.2779620	0.0003023	1.0520472	0.0000638	1.9210761	277.0794070	0.1385937
	Young	0.0071054	228.6442278	0.0435880	1680.4640133	0.0021054	7.3273473	0.0004447	13.3800007	1929.8155891	0.9649078
Total		0.4414501	14205.39318	0.4812863	18555.19415	0.5345786	1860.496858	0.6829349	20547.88522	55168.9694078	27.5844847
Energy Savings by PCA (MWh)		32,178.93		38,553.34		3,480.31		30,087.62			

### 1.1.1 2012 Results for New Residential Construction (Single-family and Multi-family), Using 2008 Base Year and 2010 eGRID

In Table 12, the combined NOx emissions reductions are listed from single-family electricity savings, multi-family electricity savings, and natural gas savings<sup>25</sup> (single-family and multi-family), which also show the 2012 annual electricity savings are shown for the combined single-family and multi-family savings.

Using the 2010 eGRID the total NOx reductions from electricity and natural gas savings from new construction in 2012 are 51.16 tons NOx/year, which represents 15.35 tons NOx/year (30.00 %) from single-family residential electricity savings, 27.58 tons NOx/year (53.91 %) from multi-family residential electricity savings, and 8.23 tons NOx/year (16.09 %) from natural gas savings from single-family and multi-family residential.

Figure 49 through Figure 52 show the electricity and NOx reductions tabulated in Table 19. Figure 49 shows the annual electricity savings by county as a stacked bar chart. Figure 50 shows the spatial distribution of the electricity savings by county across the state. Figure 51 shows the annual NOx reductions in a similar format as the electricity savings using a stacked bar chart with the ordering of the counties determined by Table 12, and Figure 52 shows the spatial distribution of the NOx savings by county across the state.

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<sup>25</sup> 0.092 lb-NOx/MMBtu of emission rate was used for the calculation.



Table 12: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences by County (Using 2008 Base year and 2010 eGRID)

County	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multifamily Houses)		Total Electricity Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total NOx Reductions
	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Annual NOx Reductions (Tons)
HARRIS	11,645.62	1.85	21,079.45	2.41	32,716.27	4.26	163,936.53	0.75	5.01
TARRANT	5,316.17	0.03	7,061.75	0.06	12,377.92	0.10	136,789.72	0.63	0.73
COLLIN	7,047.38	0.09	9,065.60	0.18	16,132.98	0.27	177,194.80	0.62	1.08
DALLAS	4,045.56	0.18	21,697.04	0.34	25,742.60	0.52	238,007.86	1.09	1.61
BEXAR	2,498.22	0.95	5,535.85	1.91	8,034.07	2.86	64,160.47	0.30	3.16
TRAVIS	4,751.38	0.35	19,389.03	0.71	24,140.41	1.07	207,348.49	0.95	2.02
DENTON	3,971.33	0.01	5,030.27	0.02	9,001.60	0.03	99,126.88	0.46	0.48
WILLIAMSON	2,529.13		3,286.06		5,825.20	0.00	58,502.78	0.27	0.27
EL PASO	2,982.07		2,514.65		5,496.72	0.00	99,009.91	0.46	0.46
MONTGOMERY	2,692.55		1,942.55		4,635.09	0.00	37,284.56	0.17	0.17
GALVESTON	1,425.53	0.28	305.33	0.37	1,730.86	0.65	20,026.31	0.09	0.74
BRAZORIA	1,535.80	0.70	730.79	0.91	2,266.60	1.61	21,647.25	0.10	1.71
COMAL	982.59		51.00		1,033.60	0.00	12,559.22	0.06	0.06
ROCKWALL	774.75		305.96		1,080.72	0.00	13,871.06	0.06	0.06
HAYS	1,530.14	0.06	4,573.99	0.11	6,104.13	0.17	54,440.45	0.25	0.42
MURKIN	924.27	0.88	429.62	1.77	1,353.89	2.65	9,377.26	0.04	2.69
FORT BEND	5,216.21	0.39	347.72	0.51	5,563.93	0.90	71,509.84	0.33	1.23
ELLIS	736.70	0.22	237.80	0.41	974.51	0.62	12,880.35	0.06	0.68
JOHNSON	638.32	0.05	971.90	0.10	1,610.21	0.15	17,457.56	0.08	0.23
GUADALUPE	634.77	0.22	0.00	0.44	634.77	0.66	7,917.05	0.04	0.70
KAUFMAN	251.36	0.43	0.00	0.81	251.36	1.24	3,696.79	0.02	1.26
JEFFERSON	411.81		733.15		1,144.96	0.00	5,980.73	0.03	0.03
PARKER	216.93	0.00	248.92	0.00	465.85	0.00	5,206.44	0.02	0.02
SMITH	205.78		231.16		436.94	0.00	3,460.87	0.02	0.02
BASTROP	40.65	0.23	0.00	0.46	40.65	0.70	1,319.89	0.01	0.70
CHAMBERS	223.01	0.25	0.00	0.33	223.01	0.59	3,093.48	0.01	0.60
GREGG	209.56		804.30		1,013.86	0.00	3,311.69	0.02	0.02
SAN PATRICK	154.96	0.10	0.00	0.21	154.96	0.31	1,564.90	0.01	0.32
LIBERTY	132.43		6.72		139.15	0.00	1,848.02	0.01	0.01
VICTORIA	93.99	0.15	56.03	0.29	150.02	0.44	1,252.71	0.01	0.44
ORANGE	140.62		0.00		140.62	0.00	1,967.30	0.01	0.01
CALDWELL	6.44		9.62		16.06	0.00	87.68	0.00	0.00
WILSON	23.48		66.70		90.17	0.00	690.44	0.00	0.00
HARLIN	72.41		128.33		200.75	0.00	1,022.48	0.00	0.00
HARRISON	32.55		11.13		43.68	0.00	546.62	0.00	0.00
WALLER	6.40		105.32		111.72	0.00	109.91	0.00	0.00
UPSHUR	12.71		62.20		74.92	0.00	968.01	0.00	0.00
RUSK	3.21	0.00	0.00	0.00	3.21	0.00	58.10	0.00	0.00
HOOD	129.47	0.37	41.36	0.69	170.82	1.06	2,260.02	0.01	1.07
HUNT	29.80	0.61	0.00	1.22	29.80	1.82	439.32	0.00	1.83
HENDERSON	131.77	0.05	29.59	0.09	161.36	0.14	2,216.27	0.01	0.15
HIDALGO	2,770.53	0.37	1,340.59	0.74	4,111.13	1.11	22,377.07	0.10	1.21
CAMERON	979.29	0.44	297.13	0.87	1,266.42	1.31	7,846.20	0.04	1.35
BELL	1,644.32		1,166.35		2,810.67	0.00	43,891.24	0.20	0.20
WEBB	590.28	0.29	1,456.47	0.58	2,046.75	0.87	6,120.35	0.03	0.89
BRAZOS	581.89	0.17	2,066.26	0.33	2,648.15	0.50	8,405.03	0.04	0.54
KENDALL	216.51		0.00		216.51	0.00	2,918.14	0.01	0.01
BURNET	180.27		0.00		180.27	0.00	2,435.22	0.01	0.01
GRAYSON	81.36		15.53		96.89	0.00	1,326.97	0.01	0.01
CORYELL	183.49		250.62		434.11	0.00	6,061.51	0.03	0.03
MIDLAND	605.08		1,104.49		1,709.57	0.00	22,919.05	0.11	0.11
LLANO	39.70	0.28	24.06	0.55	63.76	0.83	713.97	0.00	0.83
MAVERICK	59.03		7.71		66.73	0.00	598.20	0.00	0.00
MC MULLEN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
ARANSAS	81.12		14.01	0.13	95.12	0.00	919.27	0.00	0.00
WICHITA	126.76	0.01	459.85	0.02	577.61	0.04	7,642.03	0.04	0.07
TAYLOR	232.65		552.90		785.54	0.00	10,019.44	0.05	0.05
TOM GREEN	233.44		459.81		693.24	0.00	8,150.57	0.04	0.04
MCLENNAN	435.58	0.41	455.45	0.77	891.03	1.18	13,041.64	0.06	1.24
MC CULLOCH	0.00		0.00		0.00	0.00	0.00	0.00	0.00
WISE	33.29	0.07	10.37	0.14	43.66	0.21	573.49	0.00	0.22
JIM HOGG	0.00		0.00		0.00	0.00	0.00	0.00	0.00
VAL VERDE	25.22		94.16		119.38	0.00	875.85	0.00	0.00
ECTOR	586.90	0.21	1,152.98	0.42	1,739.88	0.64	23,048.89	0.11	0.74
WHARTON	64.35	0.14	0.00	0.29	64.35	0.43	851.83	0.00	0.44
KERR	49.36		0.00		49.36	0.00	666.79	0.00	0.00
PRESIDIO	3.06		5.23		8.28	0.00	99.56	0.00	0.00
JIM WELLS	31.90		0.00		31.90	0.00	322.15	0.00	0.00
CALHOUN	54.19	0.06	14.01	0.13	68.20	0.20	719.46	0.00	0.20
GILLESPIE	36.48		0.00		36.48	0.00	492.84	0.00	0.00
MATAGORDA	60.12		0.00		60.12	0.00	796.79	0.00	0.00
NAVARRO	65.92		101.21		167.13	0.00	2,285.46	0.01	0.01
ANGELINA	44.15		3.28		47.43	0.00	799.79	0.00	0.00
NACOGDOCHES	30.51		337.46		367.97	0.00	653.13	0.00	0.00
FANNIN	20.63	0.00	0.00	0.00	20.63	0.00	304.14	0.00	0.00
ATASCOSA	45.94		15.62		61.56	0.00	726.00	0.00	0.00
WASHINGTON	28.01		0.00		28.01	0.00	383.65	0.00	0.00
LAMAR	9.38	0.29	62.23	0.54	71.61	0.83	670.93	0.00	0.84
VAN ZANDT	5.74		0.00		5.74	0.00	84.40	0.00	0.00
WILLACY	35.77		0.00		35.77	0.00	283.75	0.00	0.00
BROWN	50.77		0.00		50.77	0.00	1,007.39	0.00	0.00
ERATH	45.73		21.47		67.21	0.00	1,106.93	0.01	0.01
AUSTIN	16.81		0.00		16.81	0.00	238.19	0.00	0.00
COOKE	42.40		0.00		42.40	0.00	625.18	0.00	0.00
MEDINA	12.17		23.54		35.71	0.00	292.17	0.00	0.00
TITUS	11.08	0.00	5.19	0.00	16.27	0.00	239.54	0.00	0.00
UVALDE	18.26		62.77		81.03	0.00	601.98	0.00	0.00
FAYETTE	3.20	0.36	0.00	0.71	3.20	1.07	43.85	0.00	1.07
CALLAHAN	6.96		21.47		28.43	0.00	348.51	0.00	0.00
HOPKINS	10.33		414.87		425.20	0.00	3,510.35	0.02	0.02
LAMPASAS	6.24		0.00		6.24	0.00	0.00	0.00	0.00
BLANCO	2.15		62.55		64.70	0.00	490.86	0.00	0.00
FREESTONE	8.91	0.35	0.00	0.65	8.91	0.99	176.74	0.00	0.99
GRIMES	20.01	0.00	0.00	0.00	20.01	0.00	274.04	0.00	0.00
LEE	50.44		38.47		88.92	0.00	971.90	0.00	0.00
SOMERVELL	6.67		0.00		6.67	0.00	101.99	0.00	0.00
ANDREWS	54.56	0.00	0.00	0.01	54.56	0.01	1,068.31	0.00	0.02
BORDEN	15.71		0.00		15.71	0.00	1,130.12	0.01	0.01

Table 17: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences by County (Using 2008 Base year and 2010 eGRID) (Continued)

County	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multi-family Houses)		Total Electricity Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total NOx Reductions
	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual NG Savings (Therm/County)	Annual NOx Reductions (Tons)	Annual NOx Reductions (Tons)
CHEROKEE	14.45	0.20	3.28	0.37	17.73	0.57	262.41	0.00	0.57
DIMMIT	3.94		0.00		3.94	0.00	39.83	0.00	0.00
FALLS	5.34		0.00		5.34	0.00	106.04	0.00	0.00
COLORADO	12.01		0.00		12.01	0.00	164.42	0.00	0.00
FRIO	24.55	0.00	0.00	0.00	24.55	0.00	333.30	0.00	0.00
MILAM	2.23	0.09	0.00	0.17	2.23	0.26	31.24	0.00	0.26
JACKSON	8.47		0.00		8.47	0.00	112.08	0.00	0.00
ANDERSON	4.82		0.00		4.82	0.00	87.14	0.00	0.00
HILL	1.78		0.00		1.78	0.00	35.35	0.00	0.00
CULBERSON	0.74		0.00		0.74	0.00	21.17	0.00	0.00
MASON	3.22		0.00		3.22	0.00	43.49	0.00	0.00
PECOS	6.12	0.00	0.00	0.00	6.12	0.01	164.77	0.00	0.01
RAINS	2.30		0.00		2.30	0.00	35.76	0.00	0.00
LAVACA	14.04		0.00		14.04	0.00	190.71	0.00	0.00
PALO PINTO	8.95	0.28	0.00	0.49	8.95	0.75	175.02	0.00	0.75
KIMBLE	0.00		0.00		0.00	0.00	0.00	0.00	0.00
MADISON	27.21		0.00		27.21	0.00	372.68	0.00	0.00
ARCHER	4.30		0.00		4.30	0.00	96.25	0.00	0.00
REFUGIO	8.47		0.00		8.47	0.00	112.08	0.00	0.00
LJUNESTONE	0.86	0.00	0.00	0.00	0.86	0.00	17.67	0.00	0.00
CLAY	1.07		0.00		1.07	0.00	24.96	0.00	0.00
BEE	7.62		0.00		7.62	0.00	100.87	0.00	0.00
MARTIN	4.04		0.00		4.04	0.00	79.13	0.00	0.00
GONZALES	0.87		0.00		0.87	0.00	10.85	0.00	0.00
BURLESON	28.01		0.00		28.01	0.00	383.65	0.00	0.00
KARNES	47.87		0.00		47.87	0.00	649.69	0.00	0.00
KLEBERG	16.98		0.00		16.98	0.00	184.42	0.00	0.00
BREWSTER	7.14		0.00		7.14	0.00	263.77	0.00	0.00
WINKLER	2.02		0.00		2.02	0.00	39.57	0.00	0.00
FRANKLIN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
YOUNG	28.83	0.52	0.00	0.96	28.83	1.48	563.95	0.00	1.48
HOUSTON	4.01		0.00		4.01	0.00	72.62	0.00	0.00
SCURRY	42.18		118.26		160.44	0.00	4,620.29	0.00	0.00
BOSQUE	1.78	0.18	0.00	0.30	1.78	0.46	35.35	0.00	0.46
COMANCHE	0.89		0.00		0.89	0.00	17.67	0.00	0.00
BRISCOE	6.83		0.00		6.83	0.00	270.66	0.00	0.00
CONCHO	1.02		0.00		1.02	0.00	17.46	0.00	0.00
ZAVALA	5.51		0.00		5.51	0.00	55.76	0.00	0.00
NOLAN	0.99	0.03	0.00	0.06	0.99	0.09	19.45	0.00	0.09
BROOKS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
ROBERTSON	17.61	0.27	0.00	0.54	17.61	0.82	241.15	0.00	0.82
LIVE OAK	11.85		0.00		11.85	0.00	119.67	0.00	0.00
HAMILTON	1.78		0.00		1.78	0.00	35.35	0.00	0.00
JONES	0.00		0.00		0.00	0.00	0.00	0.00	0.00
REAGAN	2.01		0.00		2.01	0.00	40.21	0.00	0.00
WARD	10.10	0.20	0.00	0.39	10.10	0.59	197.84	0.00	0.59
RED RIVER	5.97		0.00		5.97	0.00	106.38	0.00	0.00
HASKELL	1.99		0.00		1.99	0.00	38.89	0.00	0.00
HOWARD	15.15	0.13	0.00	0.26	15.15	0.39	296.75	0.00	0.39
SAN SABA	0.00		0.00		0.00	0.00	0.00	0.00	0.00
JACK	9.94	0.22	0.00	0.42	9.94	0.64	194.47	0.00	0.64
STEPHENS	2.98		0.00		2.98	0.00	56.34	0.00	0.00
RUNNELS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
REEVES	2.02		0.00		2.02	0.00	39.57	0.00	0.00
DE WITT	3.39		0.00		3.39	0.00	44.83	0.00	0.00
CHILDRESS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
CROSBY	6.62		0.00		6.62	0.00	475.84	0.00	0.00
DAWSON	9.96		0.00		9.96	0.00	700.90	0.00	0.00
MITCHELL	3.98	0.03	0.00	0.06	3.98	0.06	77.70	0.00	0.06
WILBARGER	0.00	1.31	0.00	2.44	0.00	3.75	0.00	0.00	3.75
COLEMAN	0.99		0.00		0.99	0.00	19.45	0.00	0.00
UPTON	7.02	0.00	0.00	0.00	7.02	0.01	140.74	0.00	0.01
COKE	1.02	0.00	0.00	0.00	1.02	0.00	17.70	0.00	0.00
CROCKETT	19.37		0.00		19.37	0.00	331.77	0.00	0.00
HARDEMAN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
BANDERA	0.00		0.00		0.00	0.00	0.00	0.00	0.00
BAYLOR	0.00		0.00		0.00	0.00	0.00	0.00	0.00
COTTLE	0.00		0.00		0.00	0.00	0.00	0.00	0.00
CRANE	4.01		0.00		4.01	0.00	80.42	0.00	0.00
DELTA	4.59		0.00		4.59	0.00	67.52	0.00	0.00
DICKENS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
DUVAL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
EASTLAND	0.00		0.00		0.00	0.00	0.00	0.00	0.00
EDWARDS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
FISHER	0.00		0.00		0.00	0.00	0.00	0.00	0.00
FOARD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
GLASSCOCK	0.00		0.00		0.00	0.00	0.00	0.00	0.00
GOLIAD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
HALL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
HUDSPETH	0.00		0.00		0.00	0.00	0.00	0.00	0.00
IRION	0.00		0.00		0.00	0.00	0.00	0.00	0.00
JEFF DAVIS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
KENEDY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
KENT	0.00		0.00		0.00	0.00	0.00	0.00	0.00
KING	0.00		0.00		0.00	0.00	0.00	0.00	0.00
KINNEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
KNOX	0.00		0.00		0.00	0.00	0.00	0.00	0.00
LA SALLE	3.94		19.51		23.45	0.00	59.53	0.00	0.00
LEON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
LOVING	0.00		0.00		0.00	0.00	0.00	0.00	0.00
MENARD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
MILLS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
MONTAGUE	11.46		0.00		11.46	0.00	168.97	0.00	0.00
MOTLEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
REAL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
SCHLEICHER	5.10		0.00		5.10	0.00	87.31	0.00	0.00
SHACKELFORD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
STARR	1.93		0.00		1.93	0.00	15.34	0.00	0.00
STERLING	0.00		0.00		0.00	0.00	0.00	0.00	0.00
STONEWALL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
SUTTON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
TERRELL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
THROCKMORTON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
ZAPATA	0.00		0.00		0.00	0.00	0.00	0.00	0.00
<b>TOTAL</b>	<b>75,591.15</b>	<b>15.35</b>	<b>119,591.95</b>	<b>27.58</b>	<b>195,183.10</b>	<b>42.93</b>	<b>1,789,709.33</b>	<b>8.23</b>	<b>51.16</b>

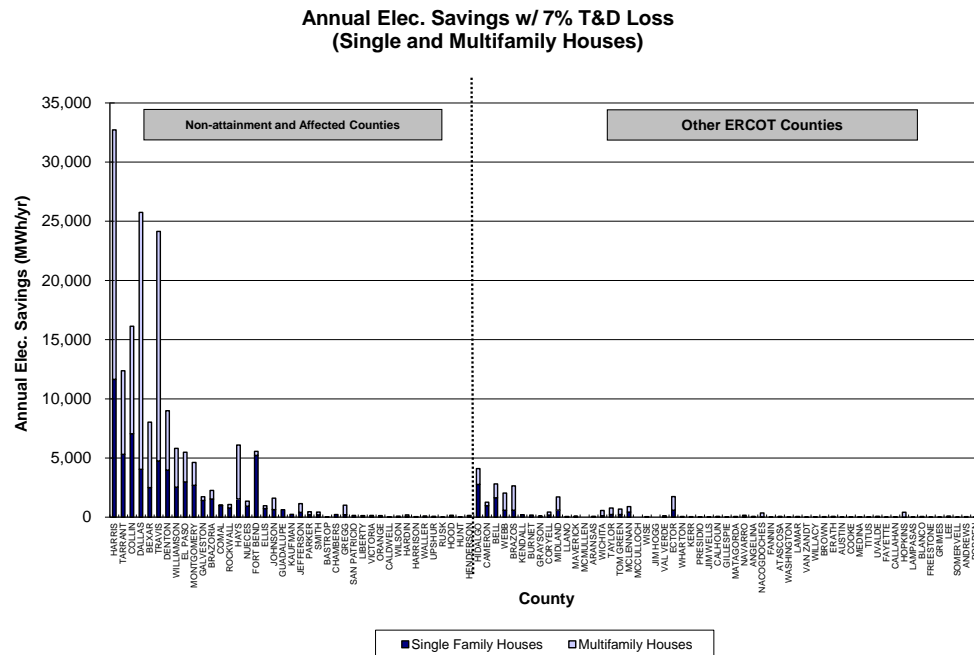


Figure 49: 2012 Annual Electricity Reductions from the 2006 IECC for Single-family and Multi-family Residences by County

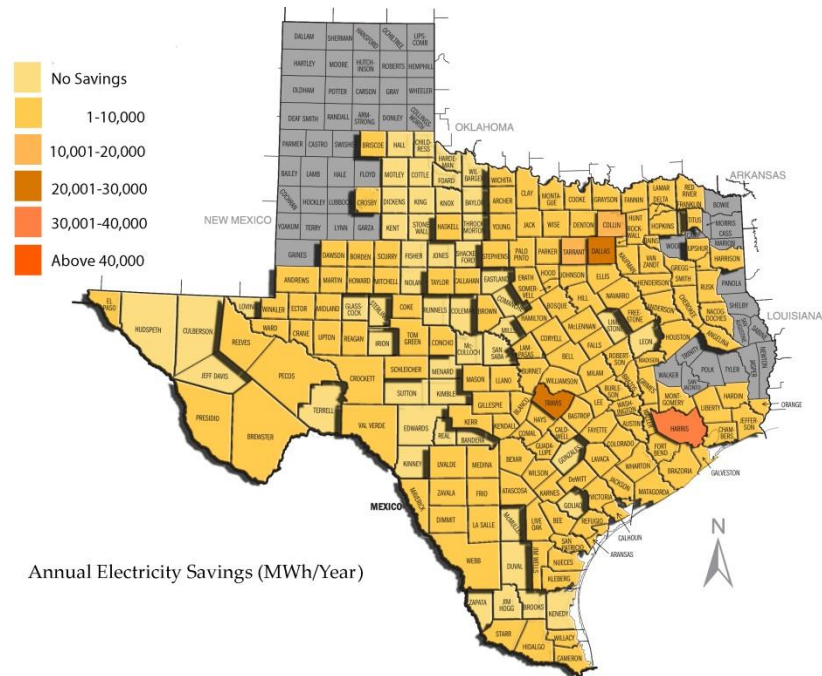


Figure 50: 2012 Annual Electricity Reductions from the 2006 IECC for Single-family and Multi-family Residences by County

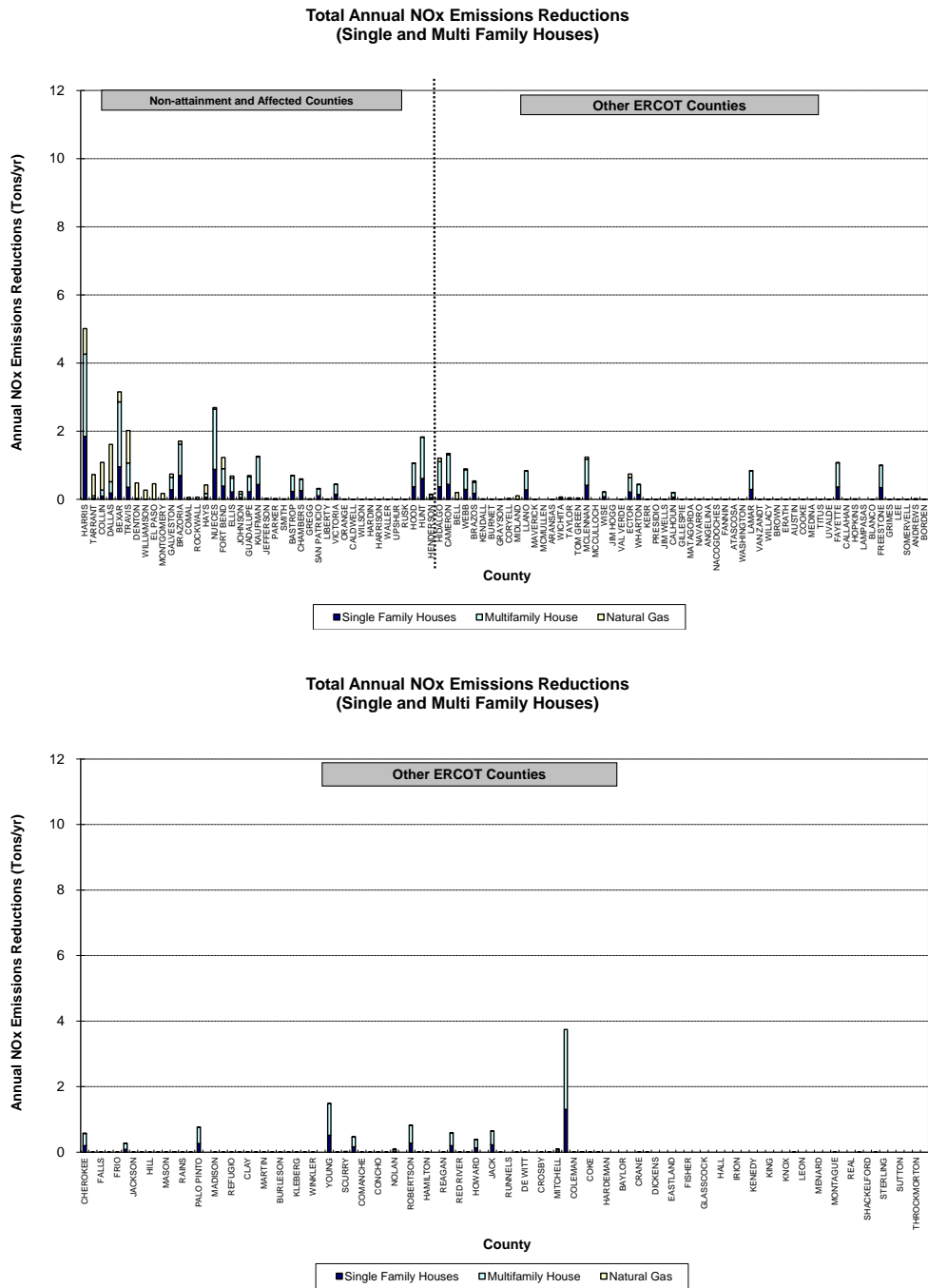


Figure 51: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences by County (using 2008 Base Year and 2010 eGRID)



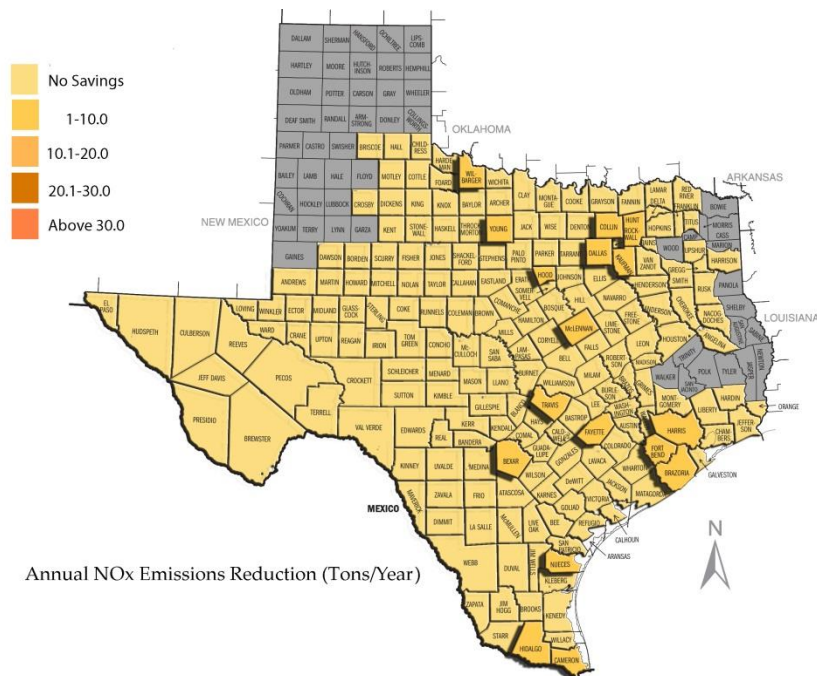


Figure 52: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences by County (Using 2008 Base year and 2010 eGRID)

#### 4.1.5 2012 Results for Commercial Construction

This section reports on the calculated energy and emissions savings from new commercial construction in 2012 that was built to meet the new ASHRAE Standard 90.1-2007 energy code. To determine the energy and emissions savings from new commercial construction in all counties in ERCOT region as well as the 41 non-attainment and affected counties, data from two sources were merged into one analysis as shown in Figure 53. In this figure, the analysis covers results shown in Figure 54 and in Table 21

Beginning in the upper left of Figure 53, the Dodge database of the square footage of new commercial construction in Texas (Dodge 2012)<sup>26</sup> was categorized with the energy savings calculations published by the United States Department of Energy (DOE) in a report. This allowed for the new construction to be tracked by county, and energy savings to be calculated by building type. In the next block in Figure 53 and Table 17, the categories from the Dodge and DOE database can be seen. This resulted in 6 Dodge categories being categorized into 7 DOE energy use categories. In the third and fourth DOE category, the Dodge “stores and restaurant” category had to be split into two categories to match the two DOE categories for “retail” and “food”. To accomplish this, information published in the 1999 and 2003 CBECS database (Table 18) by the U.S.D.O.E’s EIA was used to determine the percentages used to split the Dodge conditioned area for each county as shown (i.e., 21.06% for food and 78.94% for retail). The square footage of all DOE building types is shown by individual graphs of each building type in Figure 54

In the next step the DOE energy savings, which represent buildings built to comply with the ASHRAE Standard 90.1-2004 versus ASHRAE Standard 90.1-2007, which are expressed per square foot, were then multiplied by the published square feet of new construction. Table 19 to Table 21 show the annual energy use calculated for new construction, by building type, for ASHRAE Standard 90.1-2004 and ASHRAE Standard 90.1-2007. Table 22 shows the county-wide annual electricity and natural gas savings by building type<sup>27 28</sup>.

In the next calculation step, CM Zones were assigned to each county as shown in Table 19. In the case where more than one provider was shown in a county, a percentage of electricity use was allocated. In Table 24, the total electricity savings by CM Zones is shown for 2012 for all estimated new commercial construction. Table 24 shows the calculated annual NOx emissions reductions from electricity using the 2010 eGRID table for Texas.

**Table 25 Table 25: 2012 Annual NOx Reductions from the ASHRAE Standard 90.1-2007 for Commercial Buildings by County using 2010 eGRID (w/7% T&D)** shows the transformation of the annual county-wide electricity and natural gas savings, along with the associated 2012 NOx emissions reductions with 7% T&D losses. Figure 55 shows the bar chart of the annual electricity savings for 2012. Figure 56 presents the NOx emissions reductions from the electricity and natural gas savings using the 2010 eGRID for Texas.

Using the 2010 eGRID, the total NOx reductions from electricity and natural gas savings from new commercial construction in 2012 are calculated to be 34.27 tons NOx/year which represents 7.05 tons NOx/year from electricity savings and 27.22 tons NOx/year from natural gas savings.

<sup>26</sup> The square footage of new commercial construction of the Dodge 2011 was regarded as the square footage of new commercial construction for 2012 in this report.

<sup>27</sup> In this table (-) values are savings, (+) values are increased energy use.

<sup>28</sup> In a similar fashion as the preceding table, in this table (-) values are savings, (+) values are increased energy use.

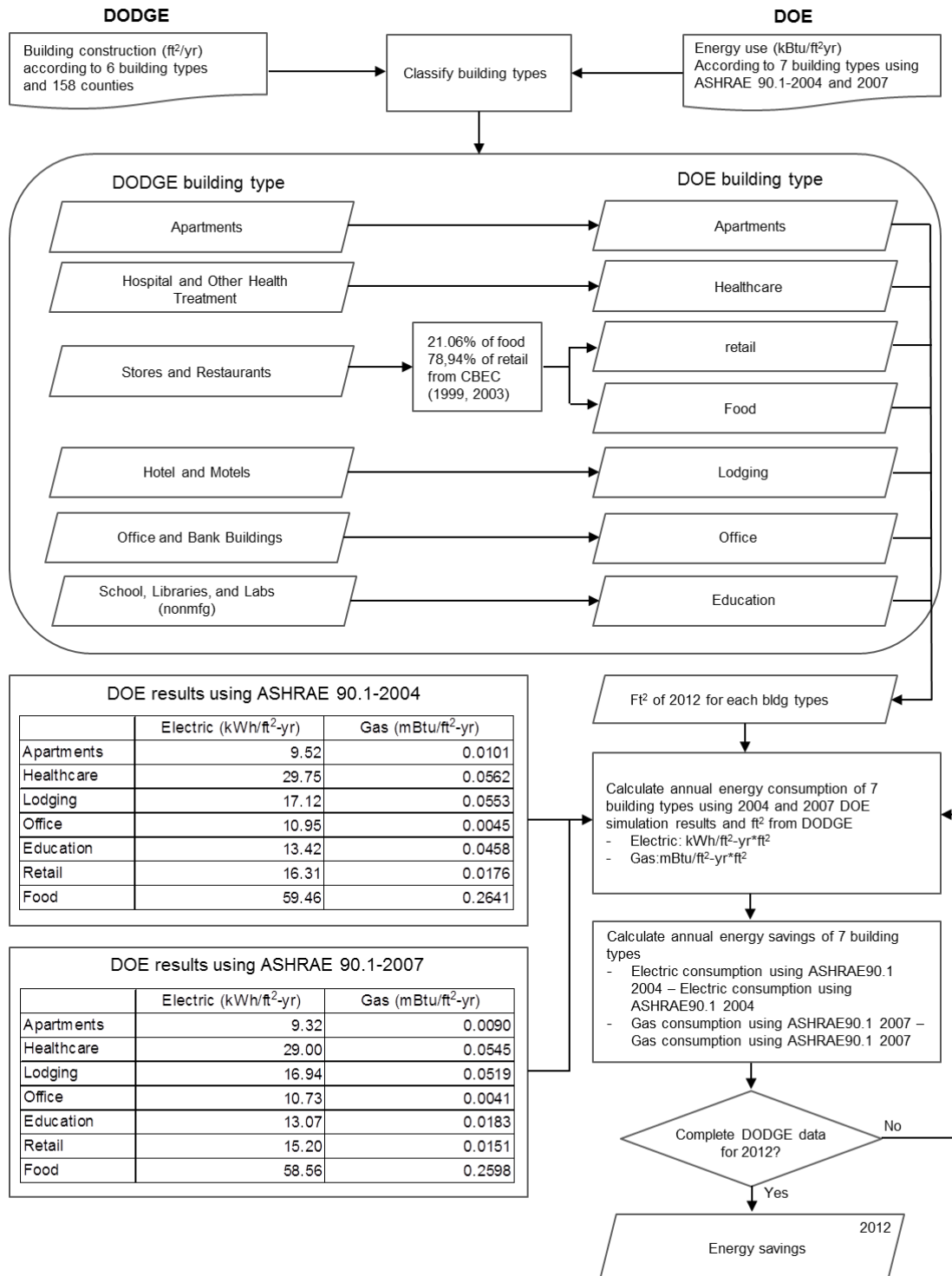


Figure 53: Analysis Method for Calculating the 2012 Energy and Emissions Savings from Commercial Buildings

Table 17: Commercial Building Descriptions from USDOE Report and Dodge (2012)

No	DOE Bldg Types	Dodge Bldg Types
1	Apartments	Apartments
2	Healthcare	Hospitals and Other Health treatment
3	Lodging	Hotels and Motels
4	Office	Office and Bank Buildings
5	Education	School, Libraries, and Labs (nonmfg)
6	Retail	Stores and Restraunts
7	Food	Stores and Restraunts

Table 18: Floor Area from CBECS (1999, 2003) database for Retail and Food Type Commercial Buildings

		CBECS (1999)		CBECS (2003)	
		All (million square feet)	South (million square feet)	All (million square feet)	South (million square feet)
Food	Food Sales	994	392	1,255	487
	Food Service	1,851	676	1,654	764
Retail	Retail (Other Than Mall)	4,766	1,566	4,317	1,844
	Enclosed and Strip Malls	5,631	2,513	6,875	3,251

	South		All	
	Food %	Retail %	Food %	Retail %
CBECS (1999)	20.75	79.25	21.48	78.52
CBECS (2003)	19.71	80.29	20.63	79.37
Average	20.23	79.77	21.06	78.94

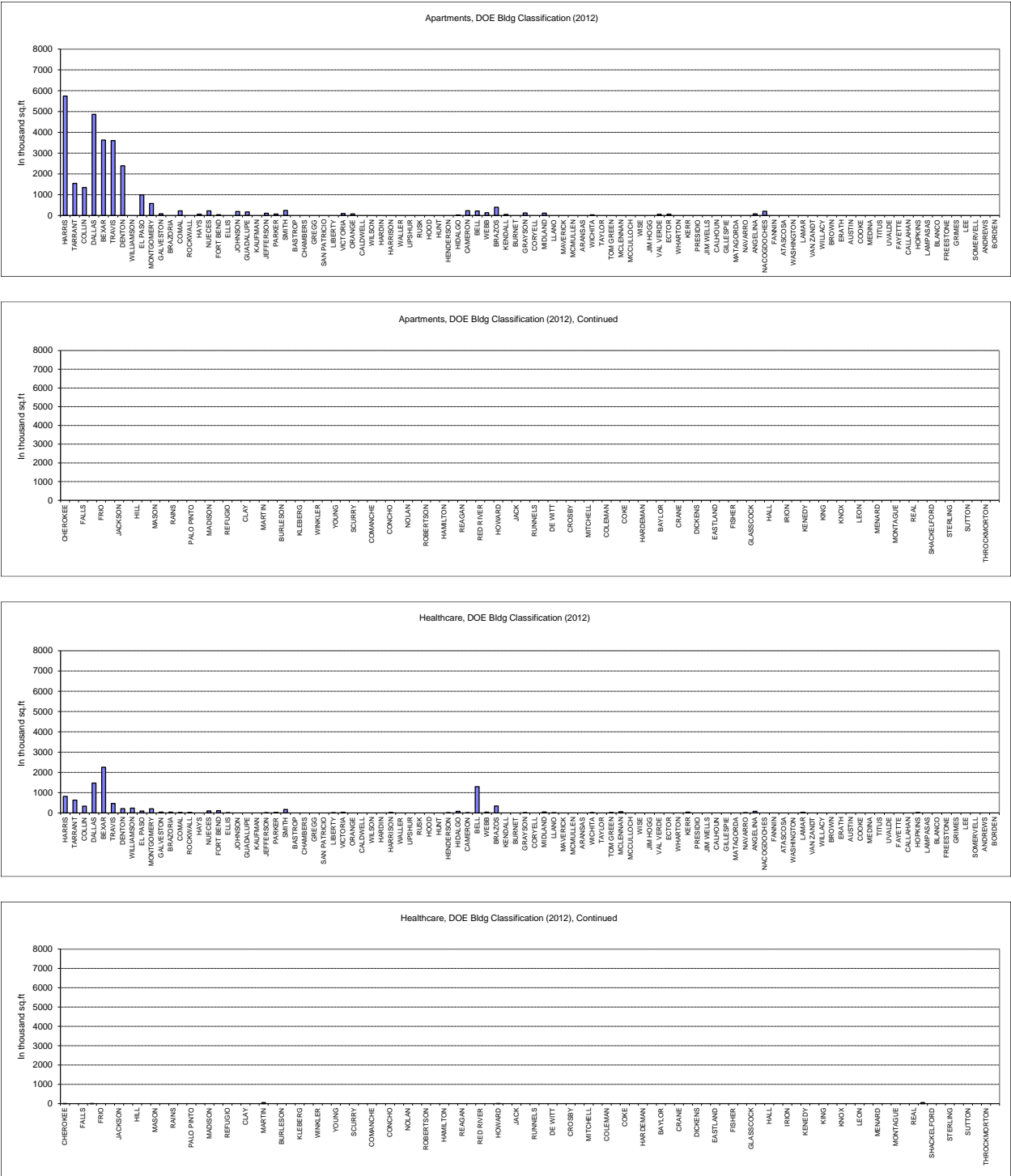


Figure 54: 2012 New Commercial Building Constructions (sq. ft. x 1000) (Dodge 2012)



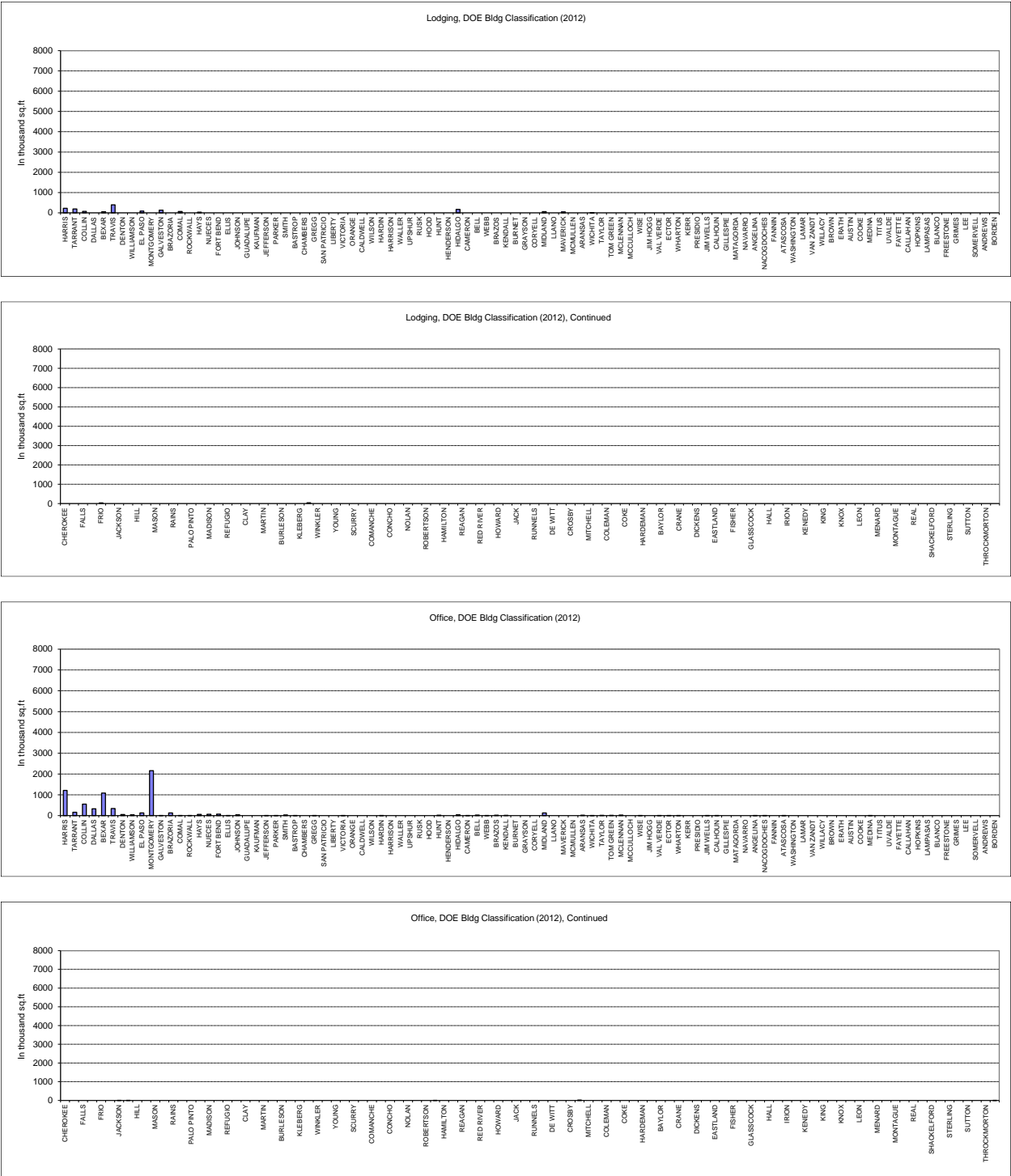


Figure 54: 2012 New Commercial Building Constructions (sq. ft. x 1000) (Dodge 2012) (Continued)

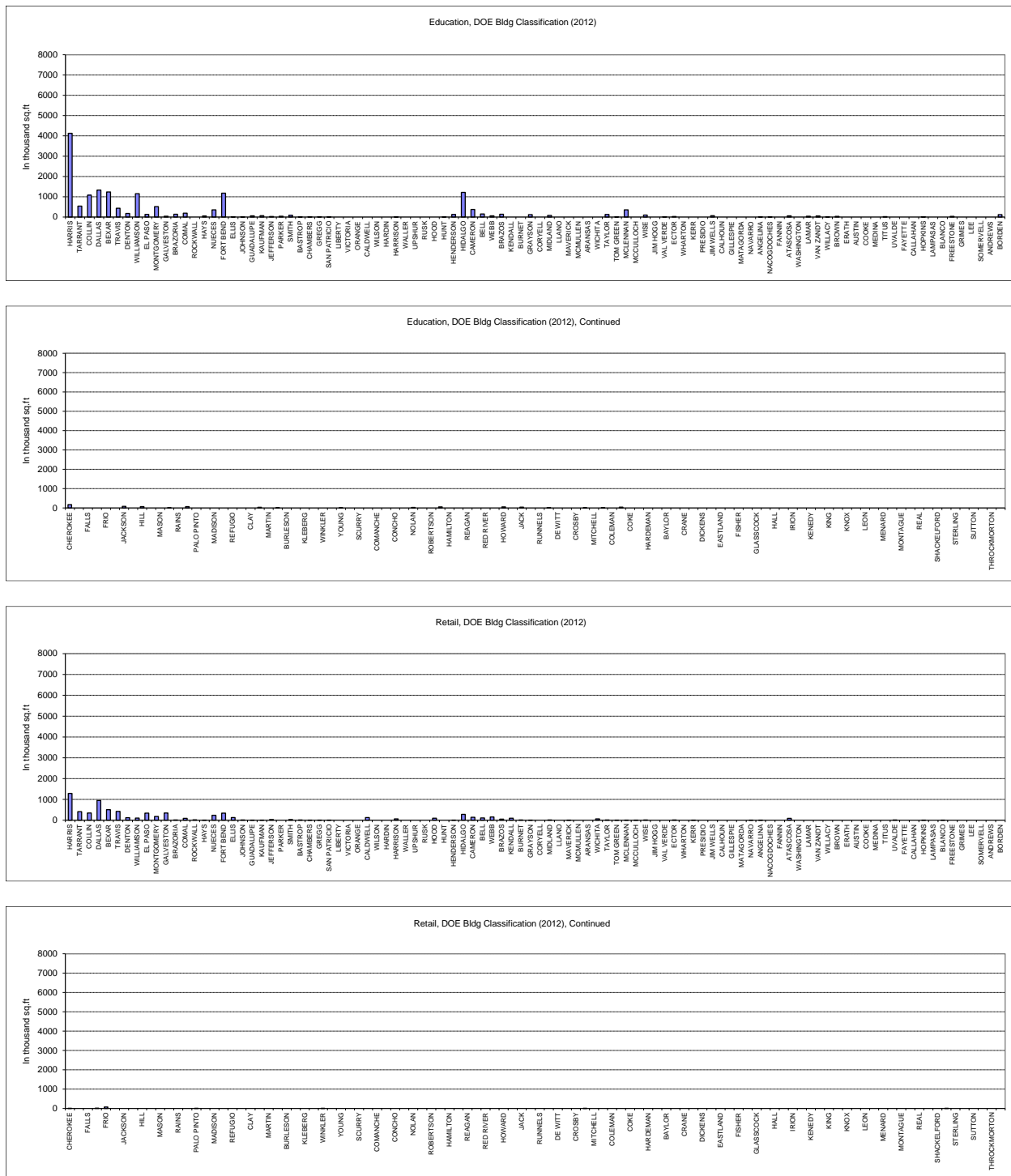


Figure 54: 2012 New Commercial Building Constructions (sq. ft. x 1000) (Dodge 2012) (Continued)

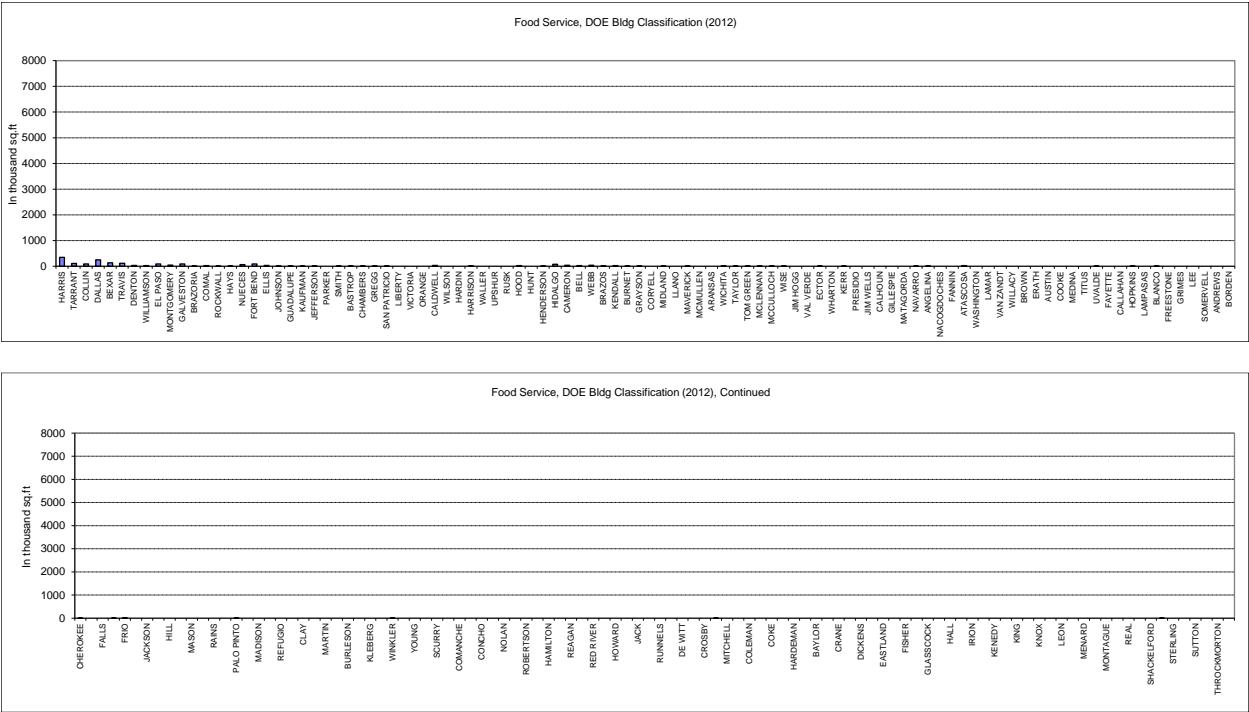


Figure 54: 2012 New Commercial Building Constructions (sq. ft. x 1000) (Dodge 2012) (Continued)

Table 19: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Apartment, Healthcare, and Lodging Building Types

Non-attainment Counties	Apartments				Healthcare				Lodging			
	Electricity (kWh/yr), DOE		Gas (m Btu/yr), DOE		Electricity (kWh/yr), DOE		Gas (m Btu/yr), DOE		Electricity (kWh/yr), DOE		Gas (m Btu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
Brazoria	0	0	0	0	1279109	1246974	2414	2344	0	0	0	0
Chambers	0	0	0	0	0	0	0	0	0	0	0	0
Collin	12805160	12529357	13578	12100	9985977	9735097	18850	18296	1232306	1219645	3978	3737
Dallas	46339174	45341100	49138	43786	43718766	42620413	82524	80099	0	0	0	0
Denton	22748114	22258155	24122	21495	6193269	6037674	11690	11347	0	0	0	0
El Paso	9437186	9233924	10007	8917	2840813	2769442	5362	5205	1427421	1412756	4608	4328
Fort Bend	388612	380242	412	367	3367330	3282732	6356	6169	0	0	0	0
Galveston	790560	773532	838	747	1154173	1125177	2179	2115	2245535	2222464	7249	6809
Hardin	0	0	0	0	0	0	0	0	0	0	0	0
Harris	54680054	53502330	57982	51667	24344722	23733106	45953	44603	3873206	3833412	12503	11745
Jefferson	1047730	1025163	1111	990	124936	121797	236	229	0	0	0	0
Liberty	0	0	0	0	187404	182696	354	343	0	0	0	0
Montgomery	5526297	5407269	5860	5222	6035611	5883978	11393	11058	0	0	0	0
Orange	761985	745573	808	720	0	0	0	0	0	0	0	0
Tarrant	14704408	14387698	15592	13894	18740439	18269620	35375	34335	3241649	3208344	10464	9830
Waller	0	0	0	0	0	0	0	0	0	0	0	0
Affected Counties	Apartments				Healthcare				Lodging			
	Electricity (kWh/yr), DOE		Gas (m Btu/yr), DOE		Electricity (kWh/yr), DOE		Gas (m Btu/yr), DOE		Electricity (kWh/yr), DOE		Gas (m Btu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
Bestrop	0	0	0	0	0	0	0	0	0	0	0	0
Bexar	34514117	33770736	36598	32612	67150263	65463237	126753	123028	936210	926592	3022	2839
Caldwell	0	0	0	0	0	0	0	0	0	0	0	0
Comal	2162133	2115564	2293	2043	553289	539389	1044	1014	1174114	1162051	3790	3560
Ellis	0	0	0	0	77341	75398	146	142	0	0	0	0
Gregg	0	0	0	0	0	0	0	0	0	0	0	0
Guadalupe	1676367	1640261	1778	1584	0	0	0	0	0	0	0	0
Harrison	0	0	0	0	565188	550989	1067	1036	0	0	0	0
Heys	603873	590867	640	571	0	0	0	0	588768	582719	1901	1785
Henderson	0	0	0	0	297467	289994	562	545	0	0	0	0
Hood	0	0	0	0	0	0	0	0	0	0	0	0
Hunt	0	0	0	0	0	0	0	0	0	0	0	0
Johnson	1819240	1780056	1929	1719	0	0	0	0	0	0	0	0
Kaufman	0	0	0	0	0	0	0	0	0	0	0	0
Nueces	2142131	2095993	2271	2024	2876509	2804242	5430	5270	0	0	0	0
Parker	707694	692451	750	669	871579	849682	1645	1597	0	0	0	0
Rockwall	0	0	0	0	755567	736585	1426	1384	0	0	0	0
Rusk	0	0	0	0	0	0	0	0	0	0	0	0
San Patricio	0	0	0	0	0	0	0	0	0	0	0	0
Smith	2348819	2298229	2491	2219	5205677	5074894	9826	9538	0	0	0	0
Trevis	34295999	33557316	36367	32406	13841152	13493419	26127	25359	6736605	6667393	21746	20428
Upshur	0	0	0	0	0	0	0	0	0	0	0	0
Victoria	952481	931966	1010	900	987591	962780	1864	1809	0	0	0	0
Williamson	0	0	0	0	7094595	6916356	13392	12998	0	0	0	0
Wilson	0	0	0	0	0	0	0	0	0	0	0	0

Table 20: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Apartment, Healthcare, and Lodging Building Types (Continued)

Other ERCOT Counties	Apartments				Healthcare				Lodging			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
ANDERSON	0	0	0	0	0	0	0	0	0	0	0	0
ANDREWS	0	0	0	0	0	0	0	0	0	0	0	0
ANGELINA	761985	745573	808	720	2349992	2290952	4436	4306	0	0	0	0
ARANSAS	0	0	0	0	0	0	0	0	0	0	0	0
ARCHER	0	0	0	0	0	0	0	0	0	0	0	0
ATASCOSA	0	0	0	0	0	0	0	0	0	0	0	0
AUSTIN	0	0	0	0	0	0	0	0	0	0	0	0
BANDERA	0	0	0	0	0	0	0	0	0	0	0	0
BAYLOR	0	0	0	0	0	0	0	0	0	0	0	0
BEE	0	0	0	0	0	0	0	0	0	0	0	0
BELL	2074505	2029823	2200	1960	38581506	37612217	72827	70687	0	0	0	0
BLANCO	0	0	0	0	0	0	0	0	0	0	0	0
BORDEN	0	0	0	0	0	0	0	0	0	0	0	0
BOSQUE	0	0	0	0	0	0	0	0	0	0	0	0
BRAZOS	3783256	3701771	4012	3575	10113887	9859795	19091	18530	0	0	0	0
BREWSTER	0	0	0	0	0	0	0	0	753076	745339	2431	2284
BRISCOE	0	0	0	0	0	0	0	0	0	0	0	0
BROOKS	0	0	0	0	0	0	0	0	0	0	0	0
BROWN	0	0	0	0	0	0	0	0	0	0	0	0
BURLESON	0	0	0	0	0	0	0	0	0	0	0	0
BURNET	0	0	0	0	0	0	0	0	0	0	0	0
CALHOUN	0	0	0	0	0	0	0	0	0	0	0	0
CALLAHAN	0	0	0	0	0	0	0	0	0	0	0	0
CAMERON	2187850	2140727	2320	2087	47595	46399	90	87	0	0	0	0
CHEROKEE	0	0	0	0	297467	289994	562	545	0	0	0	0
CHILDRESS	0	0	0	0	0	0	0	0	0	0	0	0
CLAY	0	0	0	0	0	0	0	0	0	0	0	0
COKE	0	0	0	0	0	0	0	0	0	0	0	0
COLEMAN	0	0	0	0	0	0	0	0	0	0	0	0
COLORADO	0	0	0	0	303417	295794	573	556	0	0	0	0
COMANCHE	0	0	0	0	0	0	0	0	0	0	0	0
CONCHO	0	0	0	0	0	0	0	0	0	0	0	0
COOKE	0	0	0	0	0	0	0	0	0	0	0	0
CORYELL	0	0	0	0	0	0	0	0	0	0	0	0
COTTLE	0	0	0	0	0	0	0	0	0	0	0	0
CRANE	0	0	0	0	0	0	0	0	0	0	0	0
CROCKETT	0	0	0	0	0	0	0	0	0	0	0	0
CROSBY	0	0	0	0	0	0	0	0	0	0	0	0
CULBERSON	0	0	0	0	0	0	0	0	0	0	0	0
DAWSON	0	0	0	0	0	0	0	0	0	0	0	0
DE WITT	0	0	0	0	0	0	0	0	0	0	0	0
DELTA	0	0	0	0	0	0	0	0	0	0	0	0
DICKENS	0	0	0	0	0	0	0	0	0	0	0	0
DIMMIT	0	0	0	0	0	0	0	0	0	0	0	0
DUVAL	0	0	0	0	0	0	0	0	0	0	0	0
EASTLAND	0	0	0	0	0	0	0	0	0	0	0	0
ECTOR	622923	609506	661	589	0	0	0	0	0	0	0	0
EDWARDS	0	0	0	0	0	0	0	0	0	0	0	0
ERATH	0	0	0	0	0	0	0	0	0	0	0	0
FALLS	0	0	0	0	0	0	0	0	0	0	0	0
FANNIN	0	0	0	0	0	0	0	0	0	0	0	0
FAYETTE	0	0	0	0	0	0	0	0	0	0	0	0
FISHER	0	0	0	0	0	0	0	0	0	0	0	0
FOARD	0	0	0	0	0	0	0	0	0	0	0	0
FRANKLIN	0	0	0	0	0	0	0	0	0	0	0	0
FREESTONE	0	0	0	0	0	0	0	0	0	0	0	0
FRIO	0	0	0	0	0	0	0	0	667499	660641	2155	2024
GILLESPIE	0	0	0	0	0	0	0	0	0	0	0	0
GLASSCOCK	0	0	0	0	0	0	0	0	0	0	0	0
GOLIAD	0	0	0	0	0	0	0	0	0	0	0	0
GONZALES	0	0	0	0	0	0	0	0	0	0	0	0
GRAYSON	1190602	1164958	1263	1125	348037	339293	657	638	0	0	0	0
GRIMES	0	0	0	0	0	0	0	0	0	0	0	0
HALL	0	0	0	0	0	0	0	0	0	0	0	0
HAMILTON	0	0	0	0	0	0	0	0	0	0	0	0
HARDEMAN	0	0	0	0	0	0	0	0	0	0	0	0
HASKELL	0	0	0	0	0	0	0	0	0	0	0	0
HIDALGO	254313	248835	270	240	2466004	2404050	4655	4518	2960957	2930536	9558	8979
HILL	0	0	0	0	0	0	0	0	0	0	0	0
HOPKINS	0	0	0	0	461074	449491	870	845	0	0	0	0
HOUSTON	0	0	0	0	0	0	0	0	0	0	0	0
HOWARD	0	0	0	0	32721	31899	62	60	0	0	0	0
HUDSPETH	0	0	0	0	0	0	0	0	0	0	0	0
IRION	0	0	0	0	0	0	0	0	0	0	0	0
JACK	0	0	0	0	0	0	0	0	0	0	0	0
JACKSON	0	0	0	0	0	0	0	0	0	0	0	0
JEFF DAVIS	0	0	0	0	0	0	0	0	0	0	0	0
JIM HOGG	0	0	0	0	0	0	0	0	0	0	0	0



Table 20: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Apartment, Healthcare, and Lodging Building Types (Continued)

Other ERCOT Counties	Apartments				Healthcare				Lodging			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
JIM WELLS	0	0	0	0	0	0	0	0	0	0	0	0
JONES	0	0	0	0	0	0	0	0	0	0	0	0
KARNES	0	0	0	0	0	0	0	0	0	0	0	0
KENDALL	476241	465983	505	450	0	0	0	0	0	0	0	0
KENEDY	0	0	0	0	0	0	0	0	0	0	0	0
KENT	0	0	0	0	0	0	0	0	0	0	0	0
KERR	0	0	0	0	1189869	1159976	2246	2180	0	0	0	0
KIMBLE	0	0	0	0	0	0	0	0	0	0	0	0
KING	0	0	0	0	0	0	0	0	0	0	0	0
KINNEY	0	0	0	0	0	0	0	0	0	0	0	0
KLEBERG	0	0	0	0	0	0	0	0	0	0	0	0
KNOX	0	0	0	0	0	0	0	0	0	0	0	0
LA SALLE	0	0	0	0	0	0	0	0	0	0	0	0
LAMAR	0	0	0	0	922149	898981	1741	1690	0	0	0	0
LAMPASAS	0	0	0	0	0	0	0	0	0	0	0	0
LAVACA	0	0	0	0	0	0	0	0	0	0	0	0
LEE	0	0	0	0	0	0	0	0	0	0	0	0
LEON	0	0	0	0	0	0	0	0	0	0	0	0
LIMESTONE	0	0	0	0	0	0	0	0	0	0	0	0
LIVE OAK	0	0	0	0	0	0	0	0	0	0	0	0
LLANO	0	0	0	0	267721	260995	505	491	0	0	0	0
LOVING	0	0	0	0	0	0	0	0	0	0	0	0
MADISON	0	0	0	0	0	0	0	0	0	0	0	0
MARTIN	0	0	0	0	1820500	1774763	3436	3335	0	0	0	0
MASON	0	0	0	0	0	0	0	0	0	0	0	0
MATAGORDA	0	0	0	0	0	0	0	0	0	0	0	0
MAVERICK	0	0	0	0	0	0	0	0	842076	833424	2718	2553
MCCULLOCH	0	0	0	0	0	0	0	0	0	0	0	0
MCLENNAN	0	0	0	0	1784804	1739964	3369	3270	0	0	0	0
MCMULLEN	0	0	0	0	0	0	0	0	0	0	0	0
MEDINA	0	0	0	0	0	0	0	0	0	0	0	0
MENARD	0	0	0	0	0	0	0	0	0	0	0	0
MIDLAND	1109641	1085741	1177	1049	1401071	1365672	2645	2567	1064575	1053636	3437	3228
MILAM	0	0	0	0	0	0	0	0	0	0	0	0
MILLS	0	0	0	0	0	0	0	0	0	0	0	0
MITCHELL	0	0	0	0	0	0	0	0	0	0	0	0
MONTAGUE	0	0	0	0	0	0	0	0	0	0	0	0
MOTLEY	0	0	0	0	0	0	0	0	0	0	0	0
NACOGDOCHES	1943062	1901212	2060	1836	0	0	0	0	0	0	0	0
NAVARRO	0	0	0	0	285569	278394	539	523	0	0	0	0
NOLAN	0	0	0	0	0	0	0	0	0	0	0	0
PALO PINTO	0	0	0	0	0	0	0	0	0	0	0	0
PECOS	0	0	0	0	0	0	0	0	0	0	0	0
PRESIDIO	0	0	0	0	0	0	0	0	0	0	0	0
RAINS	0	0	0	0	0	0	0	0	0	0	0	0
REAGAN	0	0	0	0	0	0	0	0	0	0	0	0
REAL	0	0	0	0	0	0	0	0	0	0	0	0
RED RIVER	0	0	0	0	0	0	0	0	0	0	0	0
REEVES	0	0	0	0	0	0	0	0	0	0	0	0
REFUGIO	0	0	0	0	0	0	0	0	0	0	0	0
ROBERTSON	0	0	0	0	0	0	0	0	0	0	0	0
RUNNELS	0	0	0	0	0	0	0	0	0	0	0	0
SAN SABA	0	0	0	0	0	0	0	0	0	0	0	0
SCHLEICHER	0	0	0	0	1749108	1705165	3302	3205	0	0	0	0
SCURRY	0	0	0	0	0	0	0	0	0	0	0	0
SHACKELFORD	0	0	0	0	0	0	0	0	0	0	0	0
SOMERVELL	0	0	0	0	0	0	0	0	0	0	0	0
STARR	0	0	0	0	0	0	0	0	0	0	0	0
STEPHENS	0	0	0	0	0	0	0	0	0	0	0	0
STERLING	0	0	0	0	0	0	0	0	0	0	0	0
STONEWALL	0	0	0	0	0	0	0	0	0	0	0	0
SUTTON	0	0	0	0	0	0	0	0	0	0	0	0
TAYLOR	0	0	0	0	0	0	0	0	0	0	0	0
TERRELL	0	0	0	0	0	0	0	0	0	0	0	0
THROCKMORTON	0	0	0	0	0	0	0	0	0	0	0	0
TITUS	0	0	0	0	0	0	0	0	0	0	0	0
TOM GREEN	0	0	0	0	538416	524889	1016	986	0	0	0	0
UPTON	0	0	0	0	0	0	0	0	0	0	0	0
UVALDE	0	0	0	0	0	0	0	0	0	0	0	0
VAL VERDE	573394	561044	608	542	0	0	0	0	0	0	0	0
VAN ZANDT	0	0	0	0	0	0	0	0	0	0	0	0
WARD	0	0	0	0	0	0	0	0	0	0	0	0
WASHINGTON	0	0	0	0	0	0	0	0	0	0	0	0
WEBB	1268705	1241379	1345	1199	1267211	1235374	2392	2322	0	0	0	0
WHARTON	0	0	0	0	0	0	0	0	0	0	0	0
WICHITA	320034	313141	339	302	461074	449491	870	845	22250	22021	72	67
WILBARGER	0	0	0	0	0	0	0	0	0	0	0	0
WILLACY	0	0	0	0	0	0	0	0	0	0	0	0
WINKLER	0	0	0	0	0	0	0	0	0	0	0	0
WISE	0	0	0	0	0	0	0	0	0	0	0	0
YOUNG	0	0	0	0	0	0	0	0	0	0	0	0
ZAPATA	0	0	0	0	0	0	0	0	0	0	0	0
ZAVALA	0	0	0	0	0	0	0	0	0	0	0	0
Total	267018645	261267474	283143	252306	284937957	277779417	537850	522045	27766246	27480977	89632	84197

Table 20: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Office and Education Building Types

Non-attainment Counties	Office				Education			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
Brazoria	1423642	1394433	585	529	1903333	1853464	6494	2588
Chambers	0	0	0	0	216105	210443	737	294
Collin	6063621	5939211	2492	2252	14453522	14074827	49317	19652
Dallas	3620432	3546150	1488	1344	17798449	17332114	60731	24200
Denton	600120	587807	247	223	2382522	2320098	8130	3239
El Paso	1437879	1408377	591	534	1773134	1726676	6050	2411
Fort Bend	788479	772301	324	293	15811895	15397610	53952	21499
Galveston	93084	91174	38	35	559725	545060	1910	761
Hardin	37234	36470	15	14	0	0	0	0
Harris	13278202	13005768	5456	4931	55398008	53946532	189026	75321
Jefferson	102940	100828	42	38	387915	377751	1324	527
Liberty	0	0	0	0	0	0	0	0
Montgomery	23631366	23146512	9711	8775	6893879	6713253	23523	9373
Orange	0	0	0	0	0	0	0	0
Tarrant	1781743	1745186	732	662	7226761	7037413	24659	9826
Waller	0	0	0	0	0	0	0	0
Affected Counties	Office				Education			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
Bastrop	61326	60068	25	23	64429	62741	220	88
Bexar	11834848	11592027	4863	4395	16554168	16120435	56485	22508
Caldwell	0	0	0	0	0	0	0	0
Comal	98560	96538	41	37	2603996	2535769	8885	3541
Ellis	96370	94392	40	36	191944	186915	655	261
Gregg	14236	13944	6	5	161072	156852	550	219
Guadalupe	0	0	0	0	765092	745046	2611	1040
Harrison	0	0	0	0	13423	13071	46	18
Hays	654875	641439	269	243	748985	729360	2556	1018
Henderson	0	0	0	0	1661725	1618187	5670	2259
Hood	0	0	0	0	0	0	0	0
Hunt	219022	214528	90	81	26845	26142	92	37
Johnson	458851	449436	189	170	67113	65355	229	91
Kaufman	0	0	0	0	880527	857456	3004	1197
Nueces	737009	721887	303	274	4747595	4623204	16199	6455
Parker	82133	80448	34	31	544960	530682	1859	741
Rockwall	49280	48269	20	18	0	0	0	0
Rusk	0	0	0	0	0	0	0	0
San Patricio	0	0	0	0	134227	130710	458	183
Smith	395335	387223	162	147	1187906	1156781	4053	1615
Travis	3706945	3630889	1523	1377	5850938	5697638	19964	7955
Upshur	0	0	0	0	0	0	0	0
Victoria	54755	53632	23	20	0	0	0	0
Williamson	429283	420475	176	159	15417269	15013323	52606	20962
Wilson	0	0	0	0	0	0	0	0

Table 21: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Office and Education Building Types (Continued)

Other ERCOT Counties	Office				Education			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
ANDERSON	15332	15017	6	6	0	0	0	0
ANDREWS	0	0	0	0	0	0	0	0
ANGELINA	32853	32179	14	12	34899	33985	119	47
ARANSAS	251875	246707	104	94	0	0	0	0
ARCHER	0	0	0	0	0	0	0	0
ATASCOSA	7666	7508	3	3	845628	823471	2885	1150
AUSTIN	0	0	0	0	0	0	0	0
BANDERA	0	0	0	0	0	0	0	0
BAYLOR	0	0	0	0	0	0	0	0
BEE	0	0	0	0	536906	522839	1832	730
BELL	286919	281032	118	107	2030849	1977639	6930	2761
BLANCO	0	0	0	0	0	0	0	0
BORDEN	0	0	0	0	1583874	1542375	5404	2154
BOSQUE	0	0	0	0	0	0	0	0
BRAZOS	226688	222037	93	84	1845616	1797259	6298	2509
BREWSTER	0	0	0	0	0	0	0	0
BRISCOE	0	0	0	0	0	0	0	0
BROOKS	0	0	0	0	0	0	0	0
BROWN	0	0	0	0	476504	464020	1626	648
BURLESON	0	0	0	0	0	0	0	0
BURNET	0	0	0	0	0	0	0	0
CALHOUN	82133	80448	34	31	0	0	0	0
CALLAHAN	0	0	0	0	0	0	0	0
CAMERON	21902	21453	9	8	4997257	4866324	17051	6794
CHEROKEE	0	0	0	0	2355677	2293956	8038	3203
CHILDRESS	0	0	0	0	0	0	0	0
CLAY	0	0	0	0	0	0	0	0
COKE	0	0	0	0	0	0	0	0
COLEMAN	0	0	0	0	0	0	0	0
COLORADO	0	0	0	0	0	0	0	0
COMANCHE	0	0	0	0	0	0	0	0
CONCHO	0	0	0	0	0	0	0	0
COOKE	0	0	0	0	0	0	0	0
CORYELL	0	0	0	0	0	0	0	0
COTTLE	0	0	0	0	0	0	0	0
CRANE	0	0	0	0	0	0	0	0
CROCKETT	0	0	0	0	0	0	0	0
CROSBY	0	0	0	0	0	0	0	0
CULBERSON	0	0	0	0	0	0	0	0
DAWSON	229973	225255	95	85	68456	66662	234	93
DE WITT	0	0	0	0	0	0	0	0
DELTA	0	0	0	0	0	0	0	0
DICKENS	0	0	0	0	0	0	0	0
DIMMIT	0	0	0	0	0	0	0	0
DUVAL	0	0	0	0	0	0	0	0
EASTLAND	0	0	0	0	0	0	0	0
ECTOR	68992	67576	28	26	402680	392129	1374	548
EDWARDS	0	0	0	0	0	0	0	0
ERATH	0	0	0	0	0	0	0	0
FALLS	0	0	0	0	0	0	0	0
FANNIN	0	0	0	0	0	0	0	0
FAYETTE	0	0	0	0	0	0	0	0
FISHER	0	0	0	0	0	0	0	0
FOARD	0	0	0	0	0	0	0	0
FRANKLIN	0	0	0	0	0	0	0	0
FREESTONE	0	0	0	0	461740	449642	1576	628
FRIO	0	0	0	0	0	0	0	0
GILLESPIE	0	0	0	0	0	0	0	0
GLASSCOCK	0	0	0	0	0	0	0	0
GOLIAD	0	0	0	0	0	0	0	0
GONZALES	0	0	0	0	134227	130710	458	183
GRAYSON	0	0	0	0	1597297	1555446	5450	2172
GRIMES	0	0	0	0	0	0	0	0
HALL	0	0	0	0	0	0	0	0
HAMILTON	0	0	0	0	0	0	0	0
HARDEMAN	0	0	0	0	0	0	0	0
HASKELL	0	0	0	0	0	0	0	0
HIDALGO	468707	459090	193	174	16315245	15887771	55670	22183
HILL	0	0	0	0	938244	913661	3201	1276
HOPKINS	0	0	0	0	167783	163387	573	228
HOUSTON	0	0	0	0	0	0	0	0
HOWARD	0	0	0	0	805360	784259	2748	1095
HUDSPETH	0	0	0	0	0	0	0	0
IRION	0	0	0	0	0	0	0	0
JACK	0	0	0	0	558383	543753	1905	759
JACKSON	37234	36470	15	14	1159718	1129332	3957	1577
JEFF DAVIS	0	0	0	0	0	0	0	0
JIM HOGG	0	0	0	0	0	0	0	0

Table 21: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Office and Education Building Types (Continued)

Other ERCOT Counties	Office				Education			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
JIM WELLS	21302	21453	9	8	900661	877062	3073	1225
JONES	0	0	0	0	0	0	0	0
KARNES	0	0	0	0	0	0	0	0
KENDALL	173027	169477	71	64	0	0	0	0
KENEDY	0	0	0	0	0	0	0	0
KENT	0	0	0	0	0	0	0	0
KERR	0	0	0	0	0	0	0	0
KIMBLE	0	0	0	0	0	0	0	0
KING	0	0	0	0	0	0	0	0
KINNEY	0	0	0	0	0	0	0	0
KLEBERG	0	0	0	0	0	0	0	0
KNOX	0	0	0	0	0	0	0	0
LA SALLE	0	0	0	0	0	0	0	0
LAMAR	0	0	0	0	561067	546367	1914	763
LAMPASAS	0	0	0	0	0	0	0	0
LAVACA	0	0	0	0	926164	901897	3160	1259
LEE	0	0	0	0	0	0	0	0
LEON	0	0	0	0	0	0	0	0
LIMESTONE	0	0	0	0	0	0	0	0
LIVE OAK	29568	28961	12	11	778514	758117	2656	1059
LLANO	0	0	0	0	0	0	0	0
LOVING	0	0	0	0	0	0	0	0
MADISON	0	0	0	0	0	0	0	0
MARTIN	0	0	0	0	0	0	0	0
MASON	0	0	0	0	0	0	0	0
MATAGORDA	0	0	0	0	0	0	0	0
MAVERICK	0	0	0	0	0	0	0	0
MCCULLOCH	0	0	0	0	0	0	0	0
MCLENNAN	277063	271378	114	103	4734173	4610133	16154	6437
MC MULLEN	0	0	0	0	0	0	0	0
MEDINA	41614	40760	17	15	0	0	0	0
MENARD	0	0	0	0	0	0	0	0
MIDLAND	1388599	1360108	571	516	1099316	1070513	3751	1495
MILAM	0	0	0	0	0	0	0	0
MILLS	0	0	0	0	0	0	0	0
MITCHELL	0	0	0	0	0	0	0	0
MONTAGUE	0	0	0	0	0	0	0	0
MOTLEY	0	0	0	0	0	0	0	0
NACOGDOCHES	48185	47196	20	18	97985	95418	334	133
NAVARRO	0	0	0	0	0	0	0	0
NOLAN	0	0	0	0	362412	352916	1237	493
PALO PINTO	0	0	0	0	0	0	0	0
PECOS	0	0	0	0	107381	104568	366	146
PRESIDIO	0	0	0	0	0	0	0	0
RAINS	0	0	0	0	0	0	0	0
REAGAN	0	0	0	0	0	0	0	0
REAL	0	0	0	0	0	0	0	0
RED RIVER	0	0	0	0	0	0	0	0
REEVES	0	0	0	0	134227	130710	458	183
REFUGIO	0	0	0	0	0	0	0	0
ROBERTSON	0	0	0	0	0	0	0	0
RUNNELS	0	0	0	0	0	0	0	0
SAN SABA	0	0	0	0	0	0	0	0
SCHLEICHER	0	0	0	0	0	0	0	0
SCURRY	0	0	0	0	0	0	0	0
SHACKELFORD	0	0	0	0	0	0	0	0
SOMERVILLE	0	0	0	0	0	0	0	0
STARR	0	0	0	0	0	0	0	0
STEPHENS	0	0	0	0	0	0	0	0
STERLING	0	0	0	0	0	0	0	0
STONEWALL	0	0	0	0	0	0	0	0
SUTTON	0	0	0	0	0	0	0	0
TAYLOR	186169	182349	77	69	1688571	1644329	5762	2296
TERRELL	0	0	0	0	0	0	0	0
THROCKMORTON	0	0	0	0	0	0	0	0
TITUS	0	0	0	0	255031	248349	870	347
TOM GREEN	155506	152315	64	58	40268	39213	137	55
UPTON	0	0	0	0	563752	548981	1924	767
UVALDE	0	0	0	0	0	0	0	0
VAL VERDE	70087	68649	29	26	218789	213057	747	297
VAN ZANDT	0	0	0	0	758380	738510	2588	1031
WARD	0	0	0	0	0	0	0	0
WASHINGTON	0	0	0	0	0	0	0	0
WEBB	43804	42906	18	16	801333	780337	2734	1090
WHARTON	61326	60068	25	23	0	0	0	0
WICHITA	64611	63286	27	24	0	0	0	0
WILBARGER	0	0	0	0	9396	9150	32	13
WILLACY	0	0	0	0	233554	227435	797	318
WINKLER	0	0	0	0	0	0	0	0
WISE	19712	19308	8	7	1339582	1304483	4571	1821
YOUNG	0	0	0	0	51006	49670	174	69
ZAPATA	108416	106191	45	40	0	0	0	0
ZAVALA	0	0	0	0	0	0	0	0
Total	76171431	74608592	31300	28286	229405364	223394743	782763	311909

Table 21: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Retail and Food Service Building Types

Non-attainment Counties	Retail				Food Service			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
Brazoria	280667	261502	302	260	273005	268834	1213	1193
Chambers	136471	127153	147	126	132745	130717	590	580
Collin	5628797	5244441	6057	5211	5475121	5391470	24317	23916
Dallas	15481767	14424612	16659	14334	15059088	14829008	66882	65781
Denton	2035482	1896492	2190	1885	1979910	1949660	8793	8649
El Paso	5521938	5144878	5942	5112	5371179	5289116	23855	23462
Fort Bend	5596611	5214452	6022	5182	5443813	5360640	24178	23780
Galveston	5610773	5227647	6038	5195	5457589	5374205	24239	23840
Hardin	0	0	0	0	0	0	0	0
Harris	21056491	19618671	22658	19495	20481611	20168684	90966	89467
Jefferson	504686	470224	543	467	490907	483407	2180	2144
Liberty	0	0	0	0	0	0	0	0
Montgomery	2961170	2758969	3186	2742	2880324	2836318	12792	12582
Orange	0	0	0	0	0	0	0	0
Tarrant	6698681	6241269	7208	6202	6515795	6416243	28939	28462
Waller	0	0	0	0	0	0	0	0
Affected Counties	Retail				Food Service			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
Bastrop	190545	177534	205	176	185343	182511	823	810
Bexar	8295137	7728713	8926	7680	8068665	7945389	35836	35245
Caldwell	2059944	1919283	2217	1907	2003704	1973090	8899	8753
Comal	1457410	1357893	1568	1349	1417621	1395961	6296	6192
Ellis	2058657	1918083	2215	1906	2002452	1971857	8894	8747
Gregg	92697	86368	100	86	90167	88789	400	394
Guadalupe	48924	45583	53	45	47588	46861	211	208
Harrison	1040272	969238	1119	963	1011870	996411	4494	4420
Hays	173808	161940	187	161	169063	166480	751	738
Henderson	29612	27590	32	27	28803	28363	128	126
Hood	1593882	1485045	1715	1476	1550366	1526679	6886	6772
Hunt	0	0	0	0	0	0	0	0
Johnson	251056	233913	270	232	244201	240470	1085	1067
Kaufman	96560	89966	104	89	93924	92489	417	410
Nueces	3858533	3595057	4152	3572	3753188	3695845	16669	16395
Parker	0	0	0	0	0	0	0	0
Rockwall	307704	286693	331	285	299303	294730	1329	1307
Rusk	0	0	0	0	0	0	0	0
San Patricio	99135	92365	107	92	96428	94955	428	421
Smith	551035	513408	593	510	535991	527802	2381	2341
Travis	6929137	6455988	7456	6415	6739959	6636983	29934	29441
Upshur	0	0	0	0	0	0	0	0
Victoria	0	0	0	0	0	0	0	0
Williamson	1709754	1593005	1840	1583	1663074	1637665	7386	7265
Wilson	0	0	0	0	0	0	0	0



Table 22: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Retail and Food Service Building Types (Continued)

Other ERCOT Counties	Retail				Food Service			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
ANDERSON	0	0	0	0	0	0	0	0
ANDREWS	0	0	0	0	0	0	0	0
ANGELINA	30899	28789	33	29	30056	29596	133	131
ARANSAS	0	0	0	0	0	0	0	0
ARCHER	0	0	0	0	0	0	0	0
ATA SCOSA	1506334	1403476	1621	1395	1465209	1442822	6507	6400
AUSTIN	0	0	0	0	0	0	0	0
BANDERA	0	0	0	0	0	0	0	0
BAYLOR	0	0	0	0	0	0	0	0
BEE	0	0	0	0	0	0	0	0
BELL	1758677	1638588	1892	1628	1710662	1684526	7598	7472
BLANCO	57936	53980	62	54	56354	55493	250	246
BORDEN	0	0	0	0	0	0	0	0
BOSQUE	0	0	0	0	0	0	0	0
BRAZOS	885776	825292	953	820	861593	848429	3827	3764
BREWSTER	0	0	0	0	0	0	0	0
BRISCOE	0	0	0	0	0	0	0	0
BROOKS	0	0	0	0	0	0	0	0
BROWN	0	0	0	0	0	0	0	0
BURLESON	0	0	0	0	0	0	0	0
BURNET	178958	166738	193	166	174072	171412	773	760
CALHOUN	0	0	0	0	0	0	0	0
CALLAHAN	0	0	0	0	0	0	0	0
CAMERON	2338037	2178386	2516	2165	2274204	2239458	10100	9934
CHEROKEE	63086	58778	68	58	61363	60426	273	268
CHILDRESS	0	0	0	0	0	0	0	0
CLAY	0	0	0	0	0	0	0	0
COKE	0	0	0	0	0	0	0	0
COLEMAN	0	0	0	0	0	0	0	0
COLORADO	245906	229114	265	228	239192	235538	1062	1045
COMANCHE	0	0	0	0	0	0	0	0
CONCHO	0	0	0	0	0	0	0	0
COOKE	0	0	0	0	0	0	0	0
CORYELL	0	0	0	0	0	0	0	0
COTTLE	0	0	0	0	0	0	0	0
CRANE	0	0	0	0	0	0	0	0
CROCKETT	0	0	0	0	0	0	0	0
CROSBY	0	0	0	0	0	0	0	0
CULBERSON	0	0	0	0	0	0	0	0
DAWSON	61798	57578	66	57	60111	59193	267	263
DE WITT	0	0	0	0	0	0	0	0
DELTA	0	0	0	0	0	0	0	0
DICKENS	0	0	0	0	0	0	0	0
DIMMIT	0	0	0	0	0	0	0	0
DUVAL	0	0	0	0	0	0	0	0
EASTLAND	0	0	0	0	0	0	0	0
ECTOR	205994	191928	222	191	200370	197309	890	875
EDWARDS	0	0	0	0	0	0	0	0
ERATH	0	0	0	0	0	0	0	0
FALLS	0	0	0	0	0	0	0	0
FANNIN	0	0	0	0	0	0	0	0
FAYETTE	0	0	0	0	0	0	0	0
FISHER	0	0	0	0	0	0	0	0
FOARD	0	0	0	0	0	0	0	0
FRANKLIN	0	0	0	0	0	0	0	0
FREESTONE	0	0	0	0	0	0	0	0
FRO	1287465	1199552	1385	1192	1252315	1233182	5562	5470
GILLESPIE	0	0	0	0	0	0	0	0
GLASSCOCK	0	0	0	0	0	0	0	0
GOLIAD	0	0	0	0	0	0	0	0
GONZALES	0	0	0	0	0	0	0	0
GRAYSON	66948	62377	72	62	65120	64125	289	284
GRIMES	0	0	0	0	0	0	0	0
HALL	0	0	0	0	0	0	0	0
HAMILTON	0	0	0	0	0	0	0	0
HARDEMAN	0	0	0	0	0	0	0	0
HASKELL	0	0	0	0	0	0	0	0
HIDALGO	4588525	4275203	4938	4248	4463251	4395059	19823	19496
HILL	0	0	0	0	0	0	0	0
HOPKINS	109435	101962	118	101	106447	104820	473	465
HOUSTON	0	0	0	0	0	0	0	0
HOWARD	0	0	0	0	0	0	0	0
HUDSPETH	0	0	0	0	0	0	0	0
IRION	0	0	0	0	0	0	0	0
JACK	0	0	0	0	0	0	0	0
JACKSON	0	0	0	0	0	0	0	0
JEFF DAVIS	0	0	0	0	0	0	0	0
JIM HOGG	0	0	0	0	0	0	0	0

Table 22: Energy Use of ASHRAE Standard 90.1-2004 and 90.1-2007 Code-Compliant Retail and Food Service Building Types (Continued)

Other ERCOT Counties	Retail				Food Service			
	Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE		Electricity (kWh/yr), DOE		Gas (mBtu/yr), DOE	
	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)	2004 (Annual)	2007 (Annual)
JIM WELLS	0	0	0	0	0	0	0	0
JONES	0	0	0	0	0	0	0	0
KARNES	0	0	0	0	0	0	0	0
KENDALL	1555258	1449059	1674	1440	1512796	1489683	6719	6608
KENEDY	0	0	0	0	0	0	0	0
KENT	0	0	0	0	0	0	0	0
KERR	119734	111558	129	111	116465	114686	517	509
KIMBLE	0	0	0	0	0	0	0	0
KING	0	0	0	0	0	0	0	0
KINNEY	0	0	0	0	0	0	0	0
KLEBERG	0	0	0	0	0	0	0	0
KNOX	0	0	0	0	0	0	0	0
LA SALLE	0	0	0	0	0	0	0	0
LAMAR	0	0	0	0	0	0	0	0
LAMPASAS	0	0	0	0	0	0	0	0
LAVACA	0	0	0	0	0	0	0	0
LEE	0	0	0	0	0	0	0	0
LEON	0	0	0	0	0	0	0	0
LIMESTONE	0	0	0	0	0	0	0	0
LIVE OAK	0	0	0	0	0	0	0	0
LLANO	0	0	0	0	0	0	0	0
LOVING	0	0	0	0	0	0	0	0
MADISON	0	0	0	0	0	0	0	0
MARTIN	0	0	0	0	0	0	0	0
MASON	0	0	0	0	0	0	0	0
MATAGORDA	0	0	0	0	0	0	0	0
MAVERICK	61798	57578	66	57	60111	59193	267	263
MCCULLOCH	38624	35987	42	36	37569	36995	167	164
MCLENNAN	93985	87567	101	87	91419	90022	406	399
MCMULLEN	0	0	0	0	0	0	0	0
MEDINA	0	0	0	0	0	0	0	0
MENARD	0	0	0	0	0	0	0	0
MIDLAND	220157	205123	237	204	214146	210874	951	935
MILAM	0	0	0	0	0	0	0	0
MILLS	0	0	0	0	0	0	0	0
MITCHELL	0	0	0	0	0	0	0	0
MONTAGUE	0	0	0	0	0	0	0	0
MOTLEY	0	0	0	0	0	0	0	0
NACOGDOCHES	0	0	0	0	0	0	0	0
NAVARRO	57936	53980	62	54	56354	55493	250	246
NOLAN	0	0	0	0	0	0	0	0
PALO PINTO	73386	68374	79	68	71382	70291	317	312
PECOS	0	0	0	0	0	0	0	0
PRESIDIO	0	0	0	0	0	0	0	0
RAINS	0	0	0	0	0	0	0	0
REAGAN	0	0	0	0	0	0	0	0
REAL	0	0	0	0	0	0	0	0
RED RIVER	0	0	0	0	0	0	0	0
REEVES	0	0	0	0	0	0	0	0
REFUGIO	0	0	0	0	0	0	0	0
ROBERTSON	0	0	0	0	0	0	0	0
RUNNELS	0	0	0	0	0	0	0	0
SAN SABA	0	0	0	0	0	0	0	0
SCHLEICHER	0	0	0	0	0	0	0	0
SCURRY	0	0	0	0	0	0	0	0
SHACKELFORD	0	0	0	0	0	0	0	0
SOMERVILLE	0	0	0	0	0	0	0	0
STARR	61798	57578	66	57	60111	59193	267	263
STEPHENS	0	0	0	0	0	0	0	0
STERLING	0	0	0	0	0	0	0	0
STONEWALL	0	0	0	0	0	0	0	0
SUTTON	0	0	0	0	0	0	0	0
TAYLOR	242043	225516	260	224	235435	231838	1046	1028
TERRELL	0	0	0	0	0	0	0	0
THROCKMORTON	0	0	0	0	0	0	0	0
TITUS	0	0	0	0	0	0	0	0
TOM GREEN	140334	130751	151	130	136502	134417	606	596
UPTON	0	0	0	0	0	0	0	0
UVALDE	180245	167937	194	167	175324	172645	779	766
VAL VERDE	0	0	0	0	0	0	0	0
VAN ZANDT	0	0	0	0	0	0	0	0
WARD	0	0	0	0	0	0	0	0
WASHINGTON	0	0	0	0	0	0	0	0
WEBB	2559481	2384709	2754	2370	2489602	2451565	11057	10875
WHARTON	0	0	0	0	0	0	0	0
WICHITA	1022247	952444	1100	946	994338	979146	4416	4343
WILBARGER	0	0	0	0	0	0	0	0
WILLACY	0	0	0	0	0	0	0	0
WINKLER	105572	98363	114	98	102690	101121	456	449
WISE	191832	178733	206	178	186595	183744	829	815
YOUNG	0	0	0	0	0	0	0	0
ZAPATA	0	0	0	0	0	0	0	0
ZAVALA	0	0	0	0	0	0	0	0
Total	122467538	114104975	131783	113386	119123957	117303926	529069	520355

Table 22: Calculated the ASHRAE Standard 90.1-2004 and 2007 Annual Electricity and Natural Gas Savings. A decrease in energy use is negative (i.e., savings); a positive value represents an energy use increase (+)

Counties	Apartments		Healthcare		Lodging		Office		Education		Retail		Food Service		Total		Total*1.07 (T&D loss) for eGrid	
	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	MWh/yr	Thermyr
<b>Non-attainment Counties</b>																		
(square feet in thousands)																		
Brazoria	0	0	-32135	-71	0	0	-29209	-56	-49869	-3907	-19165	-42	-4171	-20	-134550	-4096	144	43827
Chambers	0	0	0	0	0	0	0	0	-5662	-444	-3319	-21	-2028	-10	-17009	-474	18	5069
Collin	-275803	-1479	-250879	-554	-12661	-241	-124410	-240	-378695	-29666	-384356	-846	-83651	-401	-1510456	-33426	1616	357656
Dallas	-398075	-5352	-1038353	-2425	0	0	-74282	-143	-466335	-36531	-1057156	-2326	-230080	-1102	-3924280	-47870	4199	512300
Denton	-489959	-2627	-155594	-344	0	0	-12313	-24	-82424	-4890	-136991	-306	-30250	-145	-809532	-9335	882	98186
El Paso	-203262	-1090	-71370	-158	-14665	-279	-29502	-57	-46458	-3639	-377060	-830	-82063	-393	-824380	-6446	882	68967
Fort Bend	-8370	-45	-84598	-187	0	0	-16178	-31	-414285	-32454	-382158	-841	-83173	-398	-988763	-33956	1058	363326
Galveston	-17027	-91	-28996	-64	-23071	-440	-1910	-4	-14665	-1149	-383126	-843	-83384	-399	-552179	-2989	591	31987
Hardin	0	0	0	0	0	0	-764	-1	0	0	0	0	0	0	-764	-1	1	16
Harris	-1177224	-6315	-611616	-1360	-39793	-758	-272434	-525	-1451476	-113704	-1437820	-3163	-312928	-1498	-5303791	-127315	5675	1362265
Jefferson	-22566	-121	-3139	-7	0	0	-2112	-4	-10164	-796	-34462	-76	-7500	-36	-29943	-1040	86	11127
Liberty	0	0	-4708	-10	0	0	0	0	0	0	0	0	0	0	-4708	-10	5	111
Montgomery	-118028	-638	-151634	-335	0	0	-484854	-935	-180626	-14150	-202200	-445	-44007	-211	-1182348	-16713	1265	178832
Orange	-16412	-88	0	0	0	0	0	0	0	0	0	0	0	0	-16412	-88	18	942
Tarrant	-316710	-1698	-470819	-1040	-33305	-634	-36557	-71	-189347	-14833	-457412	-1006	-99551	-477	-1603702	-19759	1716	211416
Waller	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Affected Counties</b>																		
(square feet in thousands)																		
Bastrop	0	0	0	0	0	0	-1258	-2	-1688	-132	-13011	-29	-2832	-14	-18789	-177	20	1892
Bexar	-743381	-3986	-1687826	-3725	-9619	-183	-242820	-468	-433734	-33977	-586424	-1246	-123277	-590	-3806281	-44716	4073	472883
Caldwell	0	0	0	0	0	0	0	0	0	0	-140681	-309	-30614	-147	-171275	-456	183	4879
Cornwall	-46559	-250	-13900	-31	-12063	-230	-2022	-4	-68227	-5345	-99518	-219	-21659	-104	-263958	-6181	282	66141
Ellis	0	0	-1943	-4	0	0	-1977	-4	-5029	-394	-140573	-309	-30594	-146	-180117	-858	193	9179
Gregg	0	0	0	0	0	0	-292	-1	-4220	-331	-6330	-14	-1378	-7	-12220	-352	13	3763
Guadalupe	-36106	-194	0	0	0	0	0	0	-20046	-1570	-3141	-7	-277	-3	-60220	-1775	64	18990
Harrison	0	0	-14199	-31	0	0	0	0	-352	-28	-71034	-156	-15460	-74	-101045	-289	108	3094
Hays	-13007	-70	0	0	-6049	-115	-13436	-26	-19624	-1537	-11868	-26	-2583	-12	-66567	-1787	71	19117
Henderson	0	0	-7473	-17	0	0	0	0	-43539	-3411	-2022	-4	-440	-2	-53474	-3434	57	36741
Hood	0	0	0	0	0	0	0	0	0	0	-108836	-239	-23687	-113	-132524	-353	142	3775
Hunt	0	0	0	0	0	0	-4494	-9	-703	-55	0	0	0	0	-5197	-64	6	682
Johnson	-39184	-210	0	0	0	0	-8414	-18	-1758	-138	-17143	-38	-3731	-18	-71231	-422	76	4511
Kaufman	0	0	0	0	0	0	0	0	-23071	-1807	-6593	-15	-1435	-7	-10399	-1829	33	19567
Nueces	-46138	-247	-72267	-160	0	0	-15121	-29	-124391	-9744	-263476	-580	-57343	-275	-578736	-11035	619	118072
Parker	-15243	-82	-21897	-48	0	0	-1685	-3	-14278	-1119	0	0	0	0	-53103	-1252	57	13395
Rockwell	0	0	-18982	-42	0	0	-1011	-2	0	0	-21011	-46	-4573	-22	-45577	-112	49	1198
Rusk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Antonio	0	0	0	0	0	0	0	0	-3517	-276	-6789	-15	-1473	-7	-11759	-297	13	3183
Smith	-50590	-271	-130783	-289	0	0	-8111	-16	-31124	-2438	-37627	-83	-8189	-39	-266424	-3136	285	33553
Travis	-738683	-3961	-347733	-768	-69212	-1319	-76057	-147	-153300	-12009	-473148	-1041	-102976	-493	-1961110	-19737	2098	211183
Upshur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Victoria	-20515	-110	-24811	-55	0	0	-1123	-2	0	0	0	0	0	0	-46450	-167	50	1786
Williamson	0	0	-178239	-394	0	0	-8808	-17	-403946	-31844	-116749	-257	-25409	-122	-733150	-32433	784	347032
Wilson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 23: Calculated the ASHRAE Standard 90.1-2004 and 2007 Annual Electricity and Natural Gas Savings. A decrease in energy use is negative (i.e., savings); a positive value represents an energy use increase (+) (Continued)

Counties	Apartments		Healthcare		Lodging		Office		Education		Retail		Food Service		Total		Total*1.07 (T&D loss) for eGrid	
	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	MWh/yr	Thermyr
<i>Other ERCOT Counties</i>																		
(square feet in thousands)																		
ANDERSON	0	0	0	0	0	0	-315	-1	0	0	0	0	0	0	-315	-1	0	6
ANDREWS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANGELINA	-16412	-88	-59039	-130	0	0	-674	-1	-914	-72	-2110	-5	-459	-2	-79609	-298	85	3190
ARANSAS	0	0	0	0	0	0	-5168	-10	0	0	0	0	0	0	-5168	-10	6	107
ARCHER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATASCOSA	0	0	0	0	0	0	-157	0	-22156	-1736	-102888	-226	-22386	-107	-147558	-2069	158	22143
AUSTIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BANDERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BAYLOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEE	0	0	0	0	0	0	0	0	-14067	-1102	0	0	0	0	-14067	-1102	15	11791
BELL	-44682	-240	-969289	-2140	0	0	-5887	-11	-53210	-4168	-120089	-264	-26136	-125	-1219293	-6949	1305	74350
BLANCO	0	0	0	0	0	0	0	0	0	0	-3956	-9	-861	-4	-4812	-13	5	137
BORDEN	0	0	0	0	0	0	0	0	-41499	-3251	0	0	0	0	-41499	-3251	44	34785
BOSQUE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BRAZOS	-81486	-437	-254093	-561	0	0	-4651	-9	-48357	-3788	-60484	-133	-13164	-63	-462234	-4991	495	53405
BREWSTER	0	0	0	0	-7732	-147	0	0	0	0	0	0	0	0	-7732	-147	8	1577
BRISCOE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROOKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROWN	0	0	0	0	0	0	0	0	-12485	-978	0	0	0	0	-12485	-978	13	10465
BURLESON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BURNET	0	0	0	0	0	0	0	0	0	0	-12220	-27	-2660	-13	-14879	-40	16	424
CALHOUN	0	0	0	0	0	0	-1685	-3	0	0	0	0	0	0	-1685	-3	2	35
CALLAHAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAMERON	-47123	-253	-1196	-3	0	0	-449	-1	-130932	-10257	-159650	-351	-34746	-166	-374097	-11031	400	118028
CHEROKEE	0	0	-7473	-17	0	0	0	0	-61721	-4835	-4308	-9	-838	-4	-74439	-4865	80	52061
CHILDRESS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COKE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COLEMAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COLORADO	0	0	-7823	-17	0	0	0	0	0	0	-16791	-37	-3654	-17	-28069	-71	30	763
COMANCHE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONCHO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COOKE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COTTLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRANE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CROCKETT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CROSBY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CULBERSON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DAWSON	0	0	0	0	0	0	-4718	-9	-1794	-141	-4220	-9	-918	-4	-11650	-163	12	1747
DE WITT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DELTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DICKENS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIMMIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DUVAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EASTLAND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECTOR	-13417	-72	0	0	0	0	-1416	-3	-10551	-827	-14066	-31	-3061	-15	-42510	-947	45	10130
EDWARDS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ERATH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FALLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FANNIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAYETTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FISHER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FOARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRANKLIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 23: Calculated the ASHRAE Standard 90.1-2004 and 2007 Annual Electricity and Natural Gas Savings. A decrease in energy use is negative (i.e., savings); a positive value represents an energy use increase (+) (Continued)

Counties	Apartments		Healthcare		Lodging		Office		Education		Retail		Food Service		Total		Total*1.07 (T&D loss) for eGrid	
	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	MWh/yr	Thermyr
<i>Other ERCOT Counties</i>																		
<i>(Square feet in thousands)</i>																		
FREESTONE	0	0	0	0	0	0	0	0	-12098	-948	0	0	0	0	-12098	-948	13	10141
FRO	0	0	0	0	-6858	-131	0	0	0	0	-87913	-193	-19133	-92	-113904	-416	122	4448
GILLESPIE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLASSCOCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GOLIAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GONZALES	0	0	0	0	0	0	0	0	-3517	-276	0	0	0	0	-3517	-276	4	2948
GRAYSON	-25644	-139	-8744	-19	0	0	0	0	-41851	-3278	-4571	-10	-995	-5	-81005	-3450	88	36915
GRIMES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HALL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HAMILTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HARDEMAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HASKELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIDALGO	-5478	-29	-61954	-137	-30421	-580	-9617	-19	-427474	-33407	-313322	-689	-68192	-327	-916456	-35267	981	377358
HILL	0	0	0	0	0	0	0	0	-24583	-1926	0	0	0	0	-24583	-1926	26	20605
HOCKESS	0	0	-11584	-26	0	0	0	0	-4396	-344	-7473	-16	-1626	-8	-25079	-394	27	4218
HOUSTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOWARD	0	0	-822	-2	0	0	0	0	-21101	-1653	0	0	0	0	-21923	-1655	23	17707
HUDSPETH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JACK	0	0	0	0	0	0	0	0	-14630	-1146	0	0	0	0	-14630	-1146	16	12263
JACKSON	0	0	0	0	0	0	-764	-1	-30386	-2380	0	0	0	0	-31160	-2382	33	25495
JEFF DAVIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JIM HOGG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JIM WELLS	0	0	0	0	0	0	-449	-1	-23598	-1849	0	0	0	0	-24047	-1849	26	19789
JONES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KARNES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KENDALL	-10257	-55	0	0	0	0	-3550	-7	0	0	-106199	-234	-23113	-111	-143120	-406	153	4346
KENEDY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KENT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KERR	0	0	-29893	-66	0	0	0	0	0	0	-8176	-18	-1779	-9	-39849	-93	43	990
KIMBLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KINNEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KLEBERG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KNOX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LA SALLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAMAR	0	0	-23167	-51	0	0	0	0	-14700	-1152	0	0	0	0	-37868	-1203	41	12869
LAMPASAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAVACA	0	0	0	0	0	0	0	0	-24266	-1901	0	0	0	0	-24266	-1901	26	20340
LEE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIMESTONE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVE OAK	0	0	0	0	0	0	-607	-1	-20398	-1598	0	0	0	0	-21004	-1599	22	17110
LLANO	0	0	-6726	-15	0	0	0	0	0	0	0	0	0	0	-6726	-15	7	159
LOVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MADISON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARTIN	0	0	-45737	-101	0	0	0	0	0	0	0	0	0	0	-45737	-101	49	1080
MASON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MATA GORDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAVERICK	0	0	0	0	-8651	-165	0	0	0	0	-4220	-9	-918	-4	-13790	-179	15	1910
MCCULLOCH	0	0	0	0	0	0	0	0	0	0	-2637	-6	-574	-3	-3211	-9	3	91
MCKENNA	0	0	-44840	-99	0	0	-5685	-11	-124038	-9717	-6418	-14	-1397	-7	-182378	-9848	195	105370
MC MULLEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDINA	0	0	0	0	0	0	-854	-2	0	0	0	0	0	0	-854	-2	1	18
MENARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIDLAND	-23900	-128	-35199	-78	-10937	-208	-28490	-55	-28803	-2256	-15033	-33	-3272	-16	-145635	-2774	156	29685
MILAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MILLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MITCHELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MONTAGUE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOTLEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Table 23: Calculated the ASHRAE Standard 90.1-2004 and 2007 Annual Electricity and Natural Gas Savings. A decrease in energy use is negative (i.e., savings); a positive value represents an energy use increase (+) (Continued)

Counties	Apartments		Healthcare		Lodging		Office		Education		Retail		Food Service		Total		Total*1.07 (T&D loss) for eGrid	
	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	kWh/yr	mBtu/yr	MWh/yr	Therm/yr
<i>Other ERCOT Counties</i>																		
<i>(Square feet in thousands)</i>																		
NAACOGDOCHES	-41851	-224	0	0	0	0	-989	-2	-2567	-201	0	0	0	0	-45406	-427	49	4573
NAVARRO	0	0	-7174	-16	0	0	0	0	0	0	-3956	-9	-861	-4	-11991	-29	13	307
NOLAN	0	0	0	0	0	0	0	0	-9496	-744	0	0	0	0	-9496	-744	10	7959
PALO PINTO	0	0	0	0	0	0	0	0	0	0	-5011	-11	-1091	-5	-6102	-16	7	174
PECOS	0	0	0	0	0	0	0	0	-2813	-220	0	0	0	0	-2813	-220	3	2358
PRESIDIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RAINS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REAGAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RED RIVER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REEVES	0	0	0	0	0	0	0	0	-3517	-276	0	0	0	0	-3517	-276	4	2948
REFUGIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROBERTSON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAN SABA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCHLEICHER	0	0	-43943	-97	0	0	0	0	0	0	0	0	0	0	-43943	-97	47	1038
SCURRY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHACKELFORD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOMERVILLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STARR	0	0	0	0	0	0	0	0	0	0	-4220	-9	-918	-4	-5138	-14	5	146
STEPHENS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STERLINGS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STONEWALL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUTTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TAYLOR	0	0	0	0	0	0	-3820	-7	-44242	-3466	-16528	-36	-3597	-17	-68186	-3527	73	37736
TERRELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THROCKMORTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TITUS	0	0	0	0	0	0	0	0	-6682	-523	0	0	0	0	-6682	-523	7	5601
TOM GREEN	0	0	-13527	-30	0	0	-3191	-6	-1055	-83	-9583	-21	-2086	-10	-29440	-150	32	1602
UPTON	0	0	0	0	0	0	0	0	-14771	-1157	0	0	0	0	-14771	-1157	16	12381
UVALDE	0	0	0	0	0	0	0	0	0	0	-12308	-27	-2679	-13	-14967	-40	16	427
VAL VERDE	-12350	-66	0	0	0	0	-1438	-3	-5732	-449	0	0	0	0	-19520	-518	21	5543
VAN ZANDT	0	0	0	0	0	0	0	0	-19870	-1557	0	0	0	0	-19870	-1557	21	16655
WARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WASHINGTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WEBB	-27326	-147	-31836	-70	0	0	-899	-2	-20996	-1645	-174771	-384	-38037	-182	-293865	-2430	314	26000
WHARTON	0	0	0	0	0	0	-1258	-2	0	0	0	0	0	0	-1258	-2	26	26
WICHITA	-6893	-37	-11584	-26	-228	-4	-1326	-3	0	0	-69803	-154	-15192	-73	-105026	-296	112	3165
WILBARGER	0	0	0	0	0	0	0	0	-246	-19	0	0	0	0	-246	-19	0	206
WILLACY	0	0	0	0	0	0	0	0	-6119	-479	0	0	0	0	-6119	-479	7	5129
WINKLER	0	0	0	0	0	0	0	0	0	0	-7209	-16	-1569	-8	-8778	-23	9	250
WISE	0	0	0	0	0	0	-404	-1	-35098	-2749	-13099	-29	-2851	-14	-51453	-2793	55	29882
YOUNG	0	0	0	0	0	0	0	0	-1336	-105	0	0	0	0	-1336	-105	1	1120
ZAPATA	0	0	0	0	0	0	-2224	-4	0	0	0	0	0	0	-2224	-4	2	46
ZAVALA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-5751171	-30837	-7158540	-15805	-285270	-5435	-1562839	-3014	-6010621	-470854	-8362563	-18397	-1820031	-8714	-30951035	-553057	33118	5917709

Table 19: Totalized Annual Electricity Savings from the ASHRAE Standard 90.1-2007 by CM Zones for Commercial Buildings

CM Zones	Total Electricity Savings by CM Zones (MWh) 2012-TRY 2008
H	9,722.11
N	8,164.58
W	720.32
S	8,031.49
Total	26,638.50

Table 24: 2012 Annual NOx Reductions from the ASHRAE Standard 90.1-2007 by CM Zones for Commercial Buildings by County using 2010 eGRID

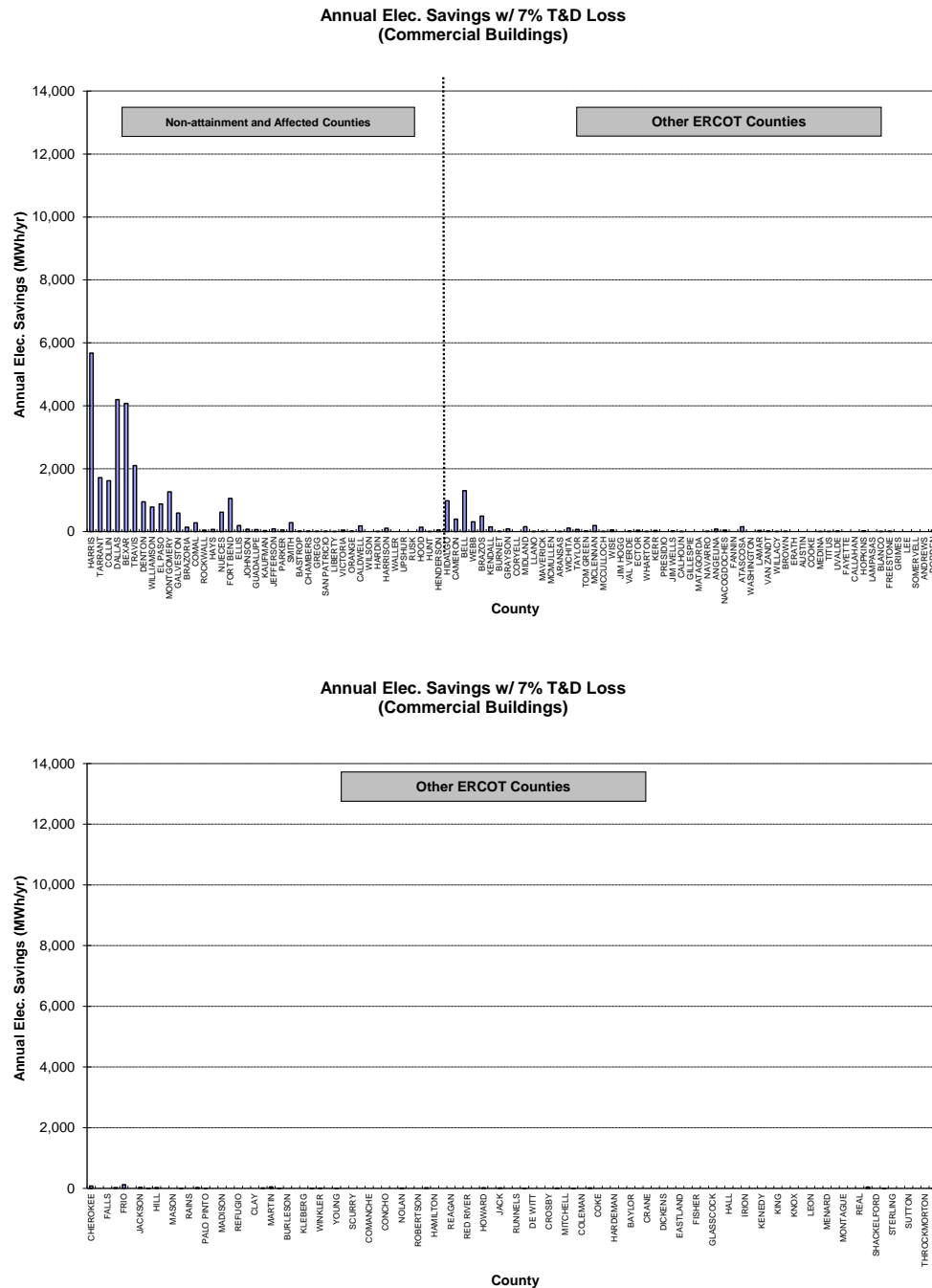
Area	County	H	NOx Reductions (lbs)	N	NOx Reductions (lbs)	W	NOx Reductions (lbs/year)	S	NOx Reductions (lbs)	Total NOx Reductions (lbs)	Total NOx Reductions (Tons)
Houston-Galveston Area	Brazoria	0.0562032	546.4136437	0.0000071	0.0582180	0.0000003	0.0002481	0.0005265	4.2289163	550.7010260	0.2753505
	Chambers	0.0204500	198.8171935	0.0000026	0.0211831	0.0000001	0.0000903	0.0001916	1.5387267	200.3771936	0.1001886
	Fort Bend	0.0313463	304.7523829	0.0000040	0.0324700	0.0000002	0.0001384	0.0002937	2.3586020	307.1435933	0.1535718
	Galveston	0.0226620	220.3221149	0.0000029	0.0234744	0.0000001	0.0001000	0.0002123	1.7051620	222.0508513	0.1110254
	Harris	0.1486911	1445.5913831	0.0000189	0.1540214	0.0000009	0.0006563	0.0013930	11.1880168	1456.9340776	0.7284670
Dallas/ Fort Worth Area	Collin	0.0012932	12.5723214	0.0079329	64.7690418	0.0003832	0.2760074	0.0000809	0.6500259	78.2673965	0.0391337
	Dallas	0.0024826	24.1361909	0.0152295	124.3428244	0.0007356	0.5298757	0.0001554	1.2479119	150.2568028	0.0751284
	Denton	0.0001267	1.2314368	0.0007770	6.3440140	0.0000375	0.0270344	0.0000079	0.0636689	7.6661542	0.0038331
	Tarrant	0.0004742	4.6100559	0.0029089	23.7497033	0.0001405	0.1012072	0.0000297	0.2383534	28.6993198	0.0143497
	Ellis	0.0029920	29.0884759	0.0183544	149.8555956	0.0008865	0.6385960	0.0001873	1.5039596	181.0866271	0.0905433
	Johnson	0.0007256	7.0543524	0.0044512	36.3420271	0.0002150	0.1548682	0.0000454	0.3647307	43.9159784	0.0219580
	Kaufman	0.0059718	58.0589641	0.0366343	299.1033517	0.0017695	1.2746018	0.0003738	3.0018188	361.4387365	0.1807194
	Parker	0.0000012	0.0119535	0.0000075	0.0615812	0.0000004	0.0002624	0.0000001	0.0006180	0.0744152	0.0000372
	Henderson	0.0006908	6.7158022	0.0042376	34.5979120	0.0002047	0.1474359	0.0000432	0.3472267	41.8083767	0.0209042
	Hood	0.0050771	49.3600792	0.0311454	254.2891581	0.0015044	1.0836302	0.0003178	2.5520609	307.2849284	0.1536425
	Hunt	0.0088463	86.0050455	0.0047066	38.4277210	0.0002273	0.1637562	0.0652823	524.3139639	648.9104867	0.3244552
	Bexar	0.0138906	135.0459832	0.0009368	7.6486931	0.0000452	0.0325942	0.1109355	890.9774568	1033.7047273	0.5168524
San Antonio Area	Guadalupe	0.0032029	31.1388393	0.0002160	1.7636321	0.0000104	0.0075156	0.0255795	205.4411630	238.3511150	0.1191756
Austin Area	Bastrop	0.0033782	32.8434634	0.0002278	1.8601780	0.0000110	0.0079270	0.0269798	216.6875666	251.3991350	0.1256996
	Hays	0.0008331	8.0997700	0.0000562	0.4587523	0.0000027	0.0019549	0.0066537	53.4389271	61.9994043	0.0309997
	Travis	0.0051785	50.3462864	0.0003493	2.8514976	0.0000169	0.0121514	0.0413577	332.1639424	385.9738777	0.1926869
	Rusk	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
Corpus Christi Area	Nueces	0.0128578	125.0047313	0.0008672	7.0799797	0.0000419	0.0301707	0.1026870	824.7294360	956.8443176	0.4784222
Victoria Area	San Patricio	0.0015100	14.6799345	0.0001018	0.8314376	0.0000049	0.0035431	0.0120591	96.8521268	112.3670420	0.0561835
	Victoria	0.0021192	20.6026646	0.0001429	1.1668874	0.0000069	0.0049726	0.0169244	135.9278465	157.7023710	0.0788512
Other ERCOT counties	Andrews	0.0000037	0.0364020	0.0000230	0.1875326	0.0000003	2.8094427	0.0000002	0.0018821	3.0352594	0.0015176
	Bosque	0.0022204	21.5872062	0.0136212	111.2111768	0.0006579	0.4739163	0.0001390	1.1161219	134.3884212	0.0671942
	Brazos	0.0024089	23.4193694	0.0112305	91.6924703	0.0005425	0.3907391	0.0047829	38.4138737	153.9164525	0.0769582
	Calhoun	0.0009466	9.2027818	0.0000638	0.5212243	0.0000031	0.0022212	0.0075598	60.7161422	70.4423695	0.0352212
	Cameron	0.0063536	61.7706921	0.0004285	3.4985496	0.0002027	0.0149088	0.0507425	407.5374393	472.8215897	0.2364109
	Cherokee	0.0027392	26.6303674	0.0168033	137.1921160	0.0008116	0.5846317	0.0001714	1.3768833	165.7839833	0.0828920
	Coke	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Ector	0.0019215	18.6811150	0.0006604	5.3915222	0.0911346	65.6460254	0.0146527	117.6828543	207.4015170	0.1037008
	Fannin	0.0000041	0.0394223	0.0000249	0.2030927	0.0000012	0.0008655	0.0000003	0.0020383	0.2454188	0.0001227
	Fayette	0.0051867	50.4256869	0.0103217	84.2721735	0.0004986	0.3591182	0.0283993	228.0886301	363.1456616	0.1815728
	Freestone	0.0047643	46.3194235	0.0292268	238.6245608	0.0014117	0.1068769	0.0002982	2.3948501	288.3557113	0.1445779
	Frio	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Grimes	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Hidalgo	0.0053716	52.2230453	0.0003623	2.9577929	0.0000175	0.0126044	0.0428994	344.5460205	399.7394631	0.1998697
	Howard	0.0002411	2.3441734	0.0007641	6.2383140	0.1283942	92.4847740	0.0009490	7.6218102	108.6890716	0.0543445
	Jack	0.0030783	29.9276995	0.0188839	154.1790381	0.0009121	0.6570200	0.0001927	1.5473499	186.3111075	0.0931556
	Lamar	0.0040001	38.8898164	0.0245388	200.3493278	0.0011853	0.8537705	0.0002504	2.0107176	242.1036323	0.1210518
	Limestone	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Llano	0.0040314	39.1941734	0.0002719	2.2198676	0.0000131	0.0094598	0.0321966	258.5869204	300.0104212	0.1500052
	McLennan	0.0056576	55.0040234	0.0347066	283.3651614	0.0016764	1.2075349	0.0003541	2.8438694	342.4205891	0.1712103
	Miami	0.0012686	12.3335288	0.0000856	0.6985426	0.0000041	0.0029768	0.0101316	81.3715138	94.4065619	0.0472033
	Mitchell	0.0000311	0.3026373	0.0001910	1.5591018	0.0324260	23.3570453	0.0000019	0.0156472	25.2344316	0.0126172
	Nolan	0.0000293	0.2844237	0.0001795	1.4652705	0.0304745	21.9513501	0.0000018	0.0147055	23.7157499	0.0118579
	Palo Pinto	0.0036129	35.1253839	0.0221635	180.9560370	0.0010705	0.7711277	0.0002261	1.8160854	218.6686341	0.1093343
	Pecos	0.0000020	0.0191520	0.0000121	0.0986655	0.0020520	1.4781166	0.0000001	0.0009902	1.5969243	0.0007985
	Robertson	0.0039506	38.4079127	0.0055755	45.5214115	0.0002693	0.1939854	0.0246170	197.7107997	281.8341093	0.1409171
	Titus	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	Upton	0.0000025	0.0247276	0.0000156	0.1273896	0.0026494	1.9084350	0.0000002	0.0012785	2.0618307	0.0010309
	Ward	0.0001995	1.9397472	0.0012239	9.9930288	0.2078335	149.7064693	0.0000125	0.1002906	161.7395360	0.0808698
	Webb	0.0042017	40.8496408	0.0002834	2.3136295	0.0000137	0.0098593	0.0335565	269.5090086	312.6821382	0.1563411
	Wharton	0.0021095	20.5089175	0.0001423	1.1615778	0.0000069	0.0049500	0.0168474	135.3093425	156.9847878	0.0784924
	Wichita	0.0000121	0.1177752	0.0000743	0.6067447	0.0126190	9.0896979	0.0000008	0.0060893	9.8203072	0.0049102
	Wilbarger	0.0179710	174.7161117	0.1102430	900.0879602	0.0053249	3.8356431	0.0011247	9.0333357	1087.6730507	0.5438365
	Wise	0.0010202	9.9183071	0.0062583	51.0963111	0.0003023	0.2177423	0.0000638	0.5128056	61.7451661	0.0308726
	Young	0.0071054	69.0794883	0.0435880	355.8779731	0.0021054	1.5165417	0.0004447	3.5716123	430.0456153	0.2150228
	Total	0.4414501	4291.82622	0.4812863	3929.500919	0.5345786	385.0671877	0.6829349	5484.983174	14091.3775012	7.0456888
Energy Savings by PCA (MWh)		9,722.11		8,164.58		720.32		8,031.49			

Table 25: 2012 Annual NOx Reductions from the ASHRAE Standard 90.1-2007 for Commercial Buildings by County using 2010 eGRID (w/7% T&amp;D)

County	Electricity Savings and Resultant NOx Reductions (Commercial)		Total Natural Gas Savings and Resultant NOx Reductions (Commercial)		Total NOx Reductions
	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Annual NOx Reductions (Tons)
HARRIS	5,675.06	0.73	1,362,265.42	6.27	6.99
TARRANT	1,715.96	0.01	211,416.18	0.97	0.99
COLLIN	1,616.19	0.04	357,656.09	1.65	1.68
DALLAS	4,198.98	0.08	512,299.61	2.36	2.43
BEXAR	4,072.72	0.52	472,682.97	2.17	2.69
TRAVIS	2,096.39	0.19	211,183.21	0.97	1.16
DENTON	951.80	0.00	89,185.98	0.41	0.41
WILLIAMSON	794.47		347,032.46	1.60	1.60
EL PASO	882.09		68,967.08	0.32	0.32
MONTGOMERY	1,265.11		178,832.38	0.82	0.82
GALVESTON	590.83	0.11	31,987.11	0.15	0.26
BRAZORIA	143.97	0.28	43,827.27	0.20	0.48
COMAL	282.44		66,141.36	0.30	0.30
ROCKWALL	48.77		1,198.17	0.01	0.01
HAYS	71.23	0.03	19,117.26	0.09	0.12
NUECES	619.25	0.48	118,071.61	0.54	1.02
FORT BEND	1,057.98	0.15	363,326.16	1.67	1.82
ELLIS	192.73	0.09	9,178.52	0.04	0.13
JOHNSON	76.22	0.02	4,510.95	0.02	0.04
GUADALUPE	64.44	0.12	18,990.15	0.09	0.21
KAUFMAN	33.28	0.18	19,566.62	0.09	0.27
JEFFERSON	85.54		11,127.18	0.05	0.05
PARKER	56.82	0.00	13,394.85	0.06	0.06
SMITH	285.07		33,553.21	0.15	0.15
BASTROP	20.10	0.13	1,892.28	0.01	0.13
CHAMBERS	18.20	0.10	5,069.30	0.02	0.12
GREGG	13.08		3,763.02	0.02	0.02
SAN PATRICK	12.58	0.06	3,182.67	0.01	0.07
LIBERTY	5.04		111.23	0.00	0.00
VICTORIA	49.70	0.08	1,786.33	0.01	0.09
ORANGE	17.56		941.60	0.00	0.00
CALDWELL	183.26		4,879.44	0.02	0.02
WILSON	0.00		0.00	0.00	0.00
HARDIN	0.82		15.76	0.00	0.00
HARRISON	108.12		3,094.35	0.01	0.01
WALLER	0.00		0.00	0.00	0.00
LIPSCHUR	0.00		0.00	0.00	0.00
RUSK	0.00	0.00	0.00	0.00	0.00
HOOD	141.80	0.15	3,775.47	0.02	0.17
HUNT	5.56	0.32	682.30	0.00	0.33
HENDERSON	57.22	0.02	36,741.07	0.17	0.19
HIDALGO	980.61	0.20	377,357.61	1.74	1.94
CAMERON	400.28	0.24	116,027.71	0.54	0.78
BELL	1,304.94		74,350.31	0.34	0.34
WEBB	314.44	0.16	25,999.78	0.12	0.28
BRAZOS	494.59	0.08	53,404.82	0.25	0.32
KENDALL	153.14		4,345.74	0.02	0.02
BURNET	15.92		423.90	0.00	0.00
GRAYSON	87.53		36,915.81	0.17	0.17
CORYELL	0.00		0.00	0.00	0.00
MIDLAND	155.83		29,684.63	0.14	0.14
LLANO	7.20	0.15	158.90	0.00	0.15
MAVERICK	14.75		1,909.96	0.01	0.01
MC MULLEN	0.00		0.00	0.00	0.00
ARANSAS	5.53		106.64	0.00	0.00
WICHITA	112.38	0.00	3,164.50	0.01	0.02
TAYLOR	72.96		37,736.11	0.17	0.17
TOM GREEN	31.50		1,602.16	0.01	0.01
MCLENNAN	195.14	0.17	105,369.90	0.48	0.66
MCCULLOCH	3.44		91.49	0.00	0.00
WISE	55.05	0.03	29,882.29	0.14	0.17
JIM HOGG	0.00		0.00	0.00	0.00
VAL VERDE	20.89		5,543.22	0.03	0.03
ECTOR	45.49	0.10	10,130.46	0.05	0.15
WHARTON	1.35	0.08	25.97	0.00	0.08
KERR	42.64		989.82	0.00	0.00
PRESIDIO	0.00		0.00	0.00	0.00
JIM WELLS	25.73		19,789.35	0.09	0.09
CALHOUN	1.80	0.04	34.78	0.00	0.04
GILLESPIE	0.00		0.00	0.00	0.00
MATAGORDA	0.00		0.00	0.00	0.00
NAVARRO	12.83		306.72	0.00	0.00
ANGELINA	85.18		3,189.89	0.01	0.01
NACOGDOCHES	48.58		4,573.41	0.02	0.02
FANNIN	0.00	0.00	0.00	0.00	0.00
ATASCOSA	157.89		22,142.79	0.10	0.10
WASHINGTON	0.00		0.00	0.00	0.00
LAMAR	40.52	0.12	12,869.32	0.06	0.18
VAN ZANDT	21.26		16,655.35	0.08	0.08
WILLACY	6.55		5,129.26	0.02	0.02
BROWN	13.36		10,464.67	0.05	0.05
ERATH	0.00		0.00	0.00	0.00
AUSTIN	0.00		0.00	0.00	0.00
COOKE	0.00		0.00	0.00	0.00
MEDINA	0.91		17.62	0.00	0.00
TITUS	7.15	0.00	5,600.92	0.03	0.03
UVALDE	16.04		426.95	0.00	0.00
FAYETTE	0.00	0.18	0.00	0.00	0.18
CALLAHAN	0.00		0.00	0.00	0.00
HOPKINS	26.83		4,217.69	0.02	0.02
LAMPASAS	0.00		0.00	0.00	0.00
BLANCO	5.15		137.23	0.00	0.00
FREESTONE	12.94	0.14	10,140.60	0.05	0.19
GRIMES	0.00	0.00	0.00	0.00	0.00
LEE	0.00		0.00	0.00	0.00
SOMERVELL	0.00		0.00	0.00	0.00
ANDREWS	0.00	0.00	0.00	0.00	0.00
BORDEN	44.40		34,784.63	0.16	0.16

Table 26: 2012 Annual NOx Reductions from the ASHRAE Standard 90.1-2007 for Commercial Buildings by County using 2010 eGRID (w/7% T&amp;D) (Continued)

County	Electricity Savings and Resultant NOx Reductions (Commercial)		Total Natural Gas Savings and Resultant NOx Reductions (Commercial)		Total NOx Reductions
	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Annual NOx Reductions (Tons)
CHEROKEE	79.65	0.08	52,060.75	0.24	0.32
DIMMIT	0.00		0.00	0.00	0.00
FALLS	0.00		0.00	0.00	0.00
COLORADO	30.03		762.56	0.00	0.00
FRIIO	121.88	0.00	4,447.60	0.02	0.02
MILAM	0.00	0.05	0.00	0.00	0.05
JACKSON	33.33		25,485.19	0.12	0.12
ANDERSON	0.34		6.49	0.00	0.00
HILL	26.30		20,805.47	0.09	0.09
CULBERSON	0.00		0.00	0.00	0.00
MASON	0.00		0.00	0.00	0.00
PECOS	3.01	0.00	2,358.28	0.01	0.01
RAINS	0.00		0.00	0.00	0.00
LAVACA	25.96		20,340.17	0.09	0.09
PALO PINTO	6.53	0.11	173.83	0.00	0.11
KIMBLE	0.00		0.00	0.00	0.00
MADISON	0.00		0.00	0.00	0.00
ARCHER	0.00		0.00	0.00	0.00
REFUGIO	0.00		0.00	0.00	0.00
LIMESTONE	0.00	0.00	0.00	0.00	0.00
CLAY	0.00		0.00	0.00	0.00
BEE	15.05		11,791.40	0.05	0.05
MARTIN	48.94		1,080.49	0.00	0.00
GONZALES	3.76		2,947.85	0.01	0.01
BURLESON	0.00		0.00	0.00	0.00
KARNES	0.00		0.00	0.00	0.00
KLEBERG	0.00		0.00	0.00	0.00
BREWSTER	8.28		1,577.18	0.01	0.01
WINKLER	9.39		250.07	0.00	0.00
FRANKLIN	0.00		0.00	0.00	0.00
YOUNG	1.43	0.22	1,120.19	0.01	0.22
HOUSTON	0.00		0.00	0.00	0.00
SCURRY	0.00		0.00	0.00	0.00
BOSQUE	0.00	0.07	0.00	0.00	0.07
COMANCHE	0.00		0.00	0.00	0.00
BRISCOE	0.00		0.00	0.00	0.00
CONCHO	0.00		0.00	0.00	0.00
ZAVALA	0.00		0.00	0.00	0.00
NOLAN	10.16	0.01	7,959.20	0.04	0.05
BROOKS	0.00		0.00	0.00	0.00
ROBERTSON	0.00	0.14	0.00	0.00	0.14
LIVE OAK	22.47		17,110.05	0.08	0.08
HAMILTON	0.00		0.00	0.00	0.00
JONES	0.00		0.00	0.00	0.00
REAGAN	0.00		0.00	0.00	0.00
WARD	0.00	0.08	0.00	0.00	0.08
RED RIVER	0.00		0.00	0.00	0.00
HASKELL	0.00		0.00	0.00	0.00
HOWARD	23.46	0.05	17,706.52	0.08	0.14
SAN SABA	0.00		0.00	0.00	0.00
JACK	15.65	0.09	12,263.06	0.06	0.15
STEPHENS	0.00		0.00	0.00	0.00
RUNNELS	0.00		0.00	0.00	0.00
REEVES	3.76		2,947.85	0.01	0.01
DE WITT	0.00		0.00	0.00	0.00
CHILDRESS	0.00		0.00	0.00	0.00
CROSBY	0.00		0.00	0.00	0.00
DAWSON	12.47		1,747.16	0.01	0.01
MITCHELL	0.00	0.01	0.00	0.00	0.01
WILBARGER	0.26	0.54	206.35	0.00	0.54
COLEMAN	0.00		0.00	0.00	0.00
UPTON	15.80	0.09	12,380.97	0.06	0.06
COKE	0.00	0.00	0.00	0.00	0.00
CROCKETT	0.00		0.00	0.00	0.00
HARDEMAN	0.00		0.00	0.00	0.00
BANDERA	0.00		0.00	0.00	0.00
BAYLOR	0.00		0.00	0.00	0.00
COTTLE	0.00		0.00	0.00	0.00
CRANE	0.00		0.00	0.00	0.00
DELTA	0.00		0.00	0.00	0.00
DICKENS	0.00		0.00	0.00	0.00
DUVAL	0.00		0.00	0.00	0.00
EASTLAND	0.00		0.00	0.00	0.00
EDWARDS	0.00		0.00	0.00	0.00
FISHER	0.00		0.00	0.00	0.00
FOARD	0.00		0.00	0.00	0.00
GLASSCOCK	0.00		0.00	0.00	0.00
GOLIAD	0.00		0.00	0.00	0.00
HALL	0.00		0.00	0.00	0.00
HUDSPETH	0.00		0.00	0.00	0.00
IRION	0.00		0.00	0.00	0.00
JEFF DAVIS	0.00		0.00	0.00	0.00
KENEDY	0.00		0.00	0.00	0.00
KENT	0.00		0.00	0.00	0.00
KING	0.00		0.00	0.00	0.00
KINNEY	0.00		0.00	0.00	0.00
KNOX	0.00		0.00	0.00	0.00
LA SALLE	0.00		0.00	0.00	0.00
LEON	0.00		0.00	0.00	0.00
LOVING	0.00		0.00	0.00	0.00
MENARD	0.00		0.00	0.00	0.00
MILLS	0.00		0.00	0.00	0.00
MONTAGUE	0.00		0.00	0.00	0.00
MOTLEY	0.00		0.00	0.00	0.00
REAL	0.00		0.00	0.00	0.00
SCHLEICHER	47.02		1,038.11	0.00	0.00
SHACKELFORD	0.00		0.00	0.00	0.00
STARR	5.50		146.38	0.00	0.00
STERLING	0.00		0.00	0.00	0.00
STONEWALL	0.00		0.00	0.00	0.00
SUTTON	0.00		0.00	0.00	0.00
TERRELL	0.00		0.00	0.00	0.00
THROCKMORTON	0.00		0.00	0.00	0.00
ZAPATA	2.38		45.90	0.00	0.00
<b>TOTAL</b>	<b>33,117.61</b>	<b>7.05</b>	<b>5,917,708.83</b>	<b>27.22</b>	<b>34.27</b>





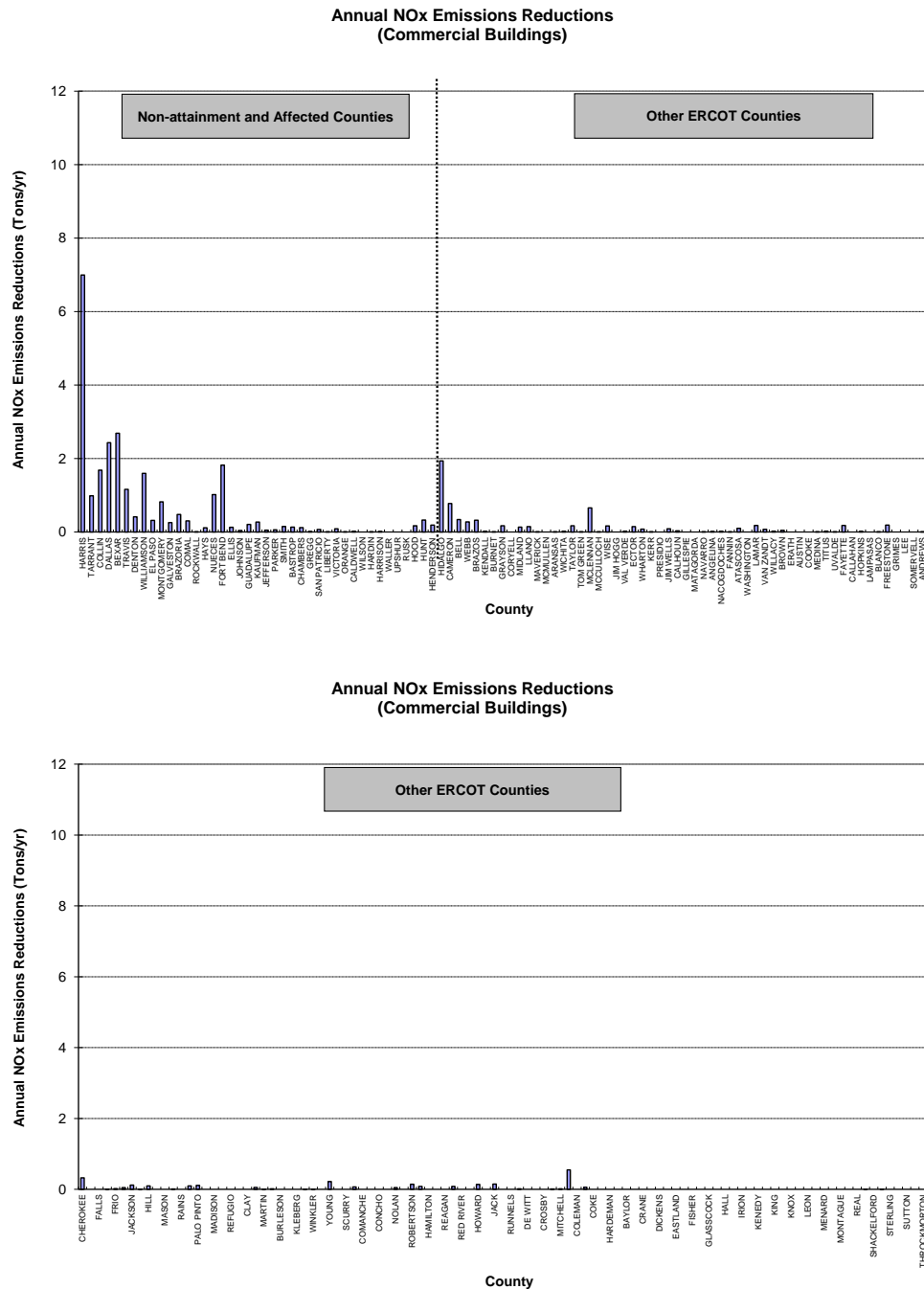


Figure 56: 2012 Annual NOx Reductions from Electricity Savings from the ASHRAE Standard 90.1-2007 for Commercial Buildings by County using 2010 eGRID with 7% T&D Losses

#### 4.1.6 2012 Results for New Residential (Single-family and Multi-family) and Commercial Construction Using 2010 eGRID

Figure 57 shows the bar chart and **Error! Reference source not found.** shows the spatial distribution of the 2012 annual electricity savings, and **Error! Reference source not found.** shows the bar chart and **Error! Reference source not found.** shows the spatial distribution of the 2012 annual NOx savings for new residential and commercial construction, respectively. As shown in Table 26, the total annual electricity savings in 2012 were calculated to be 228,300.71 MWh/yr which includes 75,591.15 MWh/yr (i.e., 33.11 %) for single-family residential, 119,591.95 MWh/yr (i.e., 52.38 %) for multi-family residential, and 33,117.61 MWh/yr (i.e., 14.51 %) for new commercial buildings. Natural gas savings were calculated to be 770,754.19 MMBtu (7,707,541.87 therms) for new residential and commercial construction.

Using the 2010 eGRID, the total NOx reductions from electricity and natural gas savings from new residential (single-family and multi-family) and commercial construction in 2012 were calculated to be 85.43 tons NOx/year which represents 49.98 tons NOx/year from electricity savings and 35.45 tons NOx/year from natural gas savings.

Table 26: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences and the ASHRAE Standard 90.1-2007 for Commercial Buildings by County (using 2010 eGRID)

	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multifamily Houses)		Electricity Savings and Resultant NOx Reductions (Commercial Buildings)		Total Electricity Savings and Resultant NOx Reductions (SF, MF and Commercial Buildings)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (SF, MF and Commercial Buildings)		Total NOx Reductions
County	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Annual NOx Reductions (Tons)
HARRIS	11,645.82	1.85	21,070.45	2.41	5,675.06	0.73	38,391.33	4.99	163,936.53	0.75	1,526,201.95	7.02	12.01
TARRANT	5,316.17	0.03	7,061.75	0.06	1,715.96	0.01	14,093.88	0.11	136,799.72	0.83	348,215.90	1.60	1.71
COLLIN	7,047.38	0.09	9,085.60	0.18	1,616.19	0.04	17,749.17	0.31	177,194.80	0.62	534,850.89	2.46	2.77
DALLAS	4,045.56	0.18	21,697.04	0.34	4,198.98	0.08	29,941.58	0.59	238,007.86	1.09	750,307.48	3.45	4.04
BEXAR	2,496.22	0.95	5,535.85	1.91	4,072.72	0.52	12,106.79	3.38	64,160.47	0.30	536,843.44	2.47	5.85
TRAVIS	4,751.38	0.35	19,389.03	0.71	2,098.39	0.19	26,238.80	1.26	207,348.49	0.95	418,531.70	1.93	3.19
DENTON	3,971.33	0.01	5,030.27	0.02	951.80	0.00	9,953.40	0.03	99,126.88	0.46	188,312.87	0.87	0.90
WILLIAMSON	2,529.13		3,296.06		784.47	0.00	6,609.67	0.00	58,502.78	0.27	405,535.24	1.87	1.87
EL PASO	2,982.07		2,514.65			0.00	6,378.81	0.00	99,009.91	0.46	167,976.99	0.77	0.77
MONTGOMERY	2,692.55		1,942.55		1,265.11	0.00	5,900.21	0.00	37,284.56	0.17	216,116.94	0.99	0.99
GALVESTON	1,425.53	0.28	305.33	0.37	590.83	0.11	2,321.70	0.75	20,026.31	0.09	52,013.42	0.24	1.00
BRAZORIA	1,535.80	0.70	730.79	0.91	143.97	0.28	2,410.56	1.89	21,647.25	0.10	65,474.52	0.30	2.19
COMAL	982.59		51.00		282.44	0.00	1,316.03	0.00	12,559.22	0.06	78,700.58	0.36	0.36
ROCKWALL	774.75		305.96		48.77	0.00	1,129.49	0.00	13,871.06	0.06	15,069.23	0.07	0.07
HAYS	1,530.14	0.06	4,573.59	0.11	71.23	0.03	6,174.96	0.20	54,440.45	0.25	73,557.72	0.34	0.54
NUECES	924.27	0.88	429.62	1.77	619.25	0.48	1,973.14	3.13	9,377.26	0.04	127,448.87	0.59	3.71
FORT BEND	5,216.21	0.39	347.72	0.51	1,057.98	0.15	6,621.90	1.05	71,509.84	0.33	434,836.00	2.00	3.05
ELLIS	736.70	0.22	237.80	0.41	192.73	0.09	1,167.23	0.71	12,880.35	0.06	22,058.88	0.10	0.82
JOHNSON	639.32	0.05	971.90	0.10	76.22	0.02	1,687.43	0.17	17,457.56	0.08	21,968.52	0.10	0.27
GUADALUPE	634.77	0.22	0.00	0.44	64.44	0.12	699.21	0.78	7,917.05	0.04	26,907.20	0.12	0.90
KAUFMAN	251.36	0.43	0.00	0.81	33.28	0.18	284.64	1.43	3,696.79	0.02	23,263.41	0.11	1.53
JEFFERSON	411.81		733.15		85.54	0.00	1,230.50	0.00	5,980.73	0.03	17,107.92	0.08	0.08
PARKER	216.93	0.00	248.92	0.00	56.82	0.00	522.67	0.00	5,205.44	0.02	18,600.29	0.09	0.09
SMITH	205.78		231.16		285.07	0.00	722.01	0.00	3,460.87	0.02	37,014.09	0.17	0.17
BASTROP	40.65	0.23	0.00	0.46	20.10	0.13	60.75	0.82	1,319.89	0.01	3,212.17	0.01	0.84
CHAMBERS	223.01	0.25	0.00	0.33	18.20	0.10	241.21	0.69	3,093.48	0.01	8,162.78	0.04	0.72
GREGG	209.56		804.30		13.08	0.00	1,026.94	0.00	3,311.69	0.02	7,074.71	0.03	0.03
SAN PATRICIO	154.96	0.10	0.00	0.21	12.58	0.06	167.54	0.37	1,564.90	0.01	4,747.58	0.02	0.39
LIBERTY	132.43		6.72		5.04	0.00	144.19	0.00	1,848.02	0.01	1,959.24	0.01	0.01
VICTORIA	93.99	0.15	56.03	0.29	49.70	0.08	199.72	0.52	1,252.71	0.01	3,039.04	0.01	0.53
ORANGE	140.62		0.00		17.56	0.00	158.19	0.00	1,967.30	0.01	2,908.90	0.01	0.01
CALDWELL	6.44		9.62		183.26	0.00	199.32	0.00	87.68	0.00	4,967.12	0.02	0.02
WILSON	23.48		66.70		0.00	0.00	90.17	0.00	690.44	0.00	690.44	0.00	0.00
HARDIN	72.41		128.33		0.82	0.00	201.56	0.00	1,038.24	0.00	1,038.24	0.00	0.00
HARRISON	32.55		11.13		108.12	0.00	151.80	0.00	546.62	0.00	3,640.97	0.02	0.02
WALLER	6.40		105.32		0.00	0.00	111.72	0.00	109.91	0.00	109.91	0.00	0.00
UPSHUR	12.71		62.20		0.00	0.00	74.92	0.00	968.01	0.00	968.01	0.00	0.00
RUSK	3.21	0.00	0.00	0.00	0.00	0.00	3.21	0.00	58.10	0.00	58.10	0.00	0.00
HOOD	129.47	0.37	41.36	0.69	141.80	0.15	312.62	1.21	2,260.02	0.01	6,036.48	0.03	1.24
HUNT	29.80	0.61	0.00	1.22	5.56	0.32	35.36	2.15	439.32	0.01	1,121.62	0.01	2.15
HENDERSON	131.77	0.05	29.59	0.09	57.22	0.02	218.58	0.16	2,218.27	0.01	38,959.34	0.18	0.34
HIDALGO	2,770.53	0.37	1,340.59	0.74	980.61	0.20	5,091.74	1.31	22,377.07	0.10	399,734.68	1.84	3.15
CAMERON	978.29	0.44	287.13	0.87	400.28	0.24	1,665.70	1.55	7,846.20	0.04	125,873.91	0.58	2.12
BELL	1,644.32		1,166.35		1,304.64	0.00	4,115.31	0.00	43,891.24	0.20	118,241.55	0.54	0.54
WEBB	590.28	0.29	1,456.47	0.58	314.44	0.16	2,381.19	1.02	6,120.35	0.03	32,120.13	0.15	1.17
BRAZOS	591.89	0.17	2,066.26	0.33	494.59	0.08	3,142.74	0.58	8,405.03	0.04	61,809.85	0.28	0.86
KENDALL	216.51		0.00		153.14	0.00	369.65	0.00	2,918.14	0.01	7,263.87	0.03	0.03
BURNET	180.27		0.00		15.92	0.00	196.19	0.00	2,435.22	0.01	2,859.13	0.01	0.01
GRAYSON	81.36		15.53		87.53	0.00	184.42	0.00	1,326.97	0.01	38,242.78	0.18	0.18
CORYELL	183.49		250.62		0.00	0.00	434.11	0.00	6,061.51	0.03	6,061.51	0.03	0.03
MIDLAND	605.08		1,104.49		155.83	0.00	1,865.40	0.00	22,919.05	0.11	52,603.67	0.24	0.24
LLANO	39.70	0.28	24.06	0.55	7.20	0.15	70.96	0.98	713.97	0.00	872.87	0.00	0.98
MAVERICK	59.03		7.71		14.75	0.00	81.49	0.00	598.20	0.00	2,508.16	0.01	0.01
MCMULLEN	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ARANSAS	81.12		0.00		5.53	0.00	86.65	0.00	819.27	0.00	925.92	0.00	0.00
WICHITA	126.76	0.01	450.85	0.02	112.38	0.00	689.99	0.04	7,642.03	0.04	10,806.53	0.05	0.09
TAYLOR	232.65		552.90		72.96	0.00	858.50	0.00	10,019.44	0.05	47,755.55	0.22	0.22
TOM GREEN	233.44		459.81		31.50	0.00	724.74	0.00	8,150.57	0.04	8,752.73	0.04	0.04
MCLENNAN	435.58	0.41	455.45	0.77	195.14	0.17	1,086.18	1.35	13,041.64	0.06	118,411.54	0.54	1.90
MCULLOCH	0.00		0.00		3.44	0.00	3.44	0.00	0.00	0.00	91.49	0.00	0.00
WISE	33.29	0.07	10.37	0.14	55.05	0.03	88.71	0.24	673.49	0.00	30,455.78	0.14	0.38
JIM HOGG	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VAL VERDE	25.22		94.16		20.89	0.00	140.26	0.00	875.85	0.00	6,419.08	0.03	0.03
ECTOR	586.90	0.21	1,152.98	0.42	45.49	0.10	1,785.36	0.74	23,048.89	0.11	33,179.35	0.15	0.89
WHARTON	64.35	0.14	0.00	0.29	1.35	0.08	65.70	0.51	851.83	0.00	877.79	0.00	0.52
KERR	49.36		0.00		42.64	0.00	92.00	0.00	666.79	0.00	1,656.61	0.01	0.01
PRESIDIO	3.06		5.23		0.00	0.00	8.28	0.00	95.56	0.00	95.56	0.00	0.00
JIM WELLS	31.90		0.00		25.73	0.00	57.63	0.00	322.19	0.00	20,111.53	0.09	0.09
CALHOUN	54.19	0.06	14.01	0.13	1.80	0.04	70.00	0.23	719.48	0.00	754.25	0.00	0.23
GILLESPIE	36.48		0.00		0.00	0.00	36.48	0.00	492.84	0.00	492.84	0.00	0.00
MATAGORDA	60.12		0.00		0.00	0.00	60.12	0.00	795.79	0.00	795.79	0.00	0.00
NAVARRO	65.92		101.21		12.83	0.00	179.96	0.00	2,285.46	0.01	2,592.18	0.01	0.01
ANGELINA	44.15		3.28		85.18	0.00	132.61	0.00	799.79	0.00	3,989.68	0.02	0.02
NACOGDOCHES	30.51		337.46		48.58	0.00	416.55	0.00	653.13	0.00	5,226.54	0.02	0.02
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Table 27: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences and the ASHRAE Standard 90.1-2007 for Commercial Buildings by County (using 2010 eGRID) (Continued)

County	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multifamily Houses)		Electricity Savings and Resultant NOx Reductions (Commercial Buildings)		Total Electricity Savings and Resultant NOx Reductions (SF, MF and Commercial Buildings)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (SF, MF and Commercial Buildings)		Total NOx Reductions
	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual NOx Reductions (Tons)	Annual NOx Reductions (Tons)
CHEROKEE	14.45	0.20	3.28	0.37	79.65	0.08	97.38	0.65	262.41	0.00	52,323.16	0.24	0.89
DIMMIT	3.94	0.00	0.00	0.00	0.00	0.00	3.94	0.00	39.83	0.00	39.83	0.00	0.00
FALLS	5.34	0.00	0.00	0.00	0.00	0.00	5.34	0.00	106.04	0.00	106.04	0.00	0.00
COLORADO	12.01	0.00	0.00	0.00	30.03	0.00	42.04	0.00	164.42	0.00	506.99	0.00	0.00
FRIO	24.55	0.00	0.00	0.00	121.88	0.00	146.43	0.00	333.30	0.00	4,780.90	0.02	0.02
MILAM	2.23	0.09	0.00	0.17	0.00	0.05	2.23	0.31	31.24	0.00	31.24	0.00	0.31
JACKSON	8.47	0.00	0.00	0.00	33.33	0.00	41.80	0.00	112.08	0.00	25,597.27	0.12	0.12
ANDERSON	4.82	0.00	0.00	0.00	0.34	0.00	5.15	0.00	87.14	0.00	93.63	0.00	0.00
HILL	1.78	0.00	0.00	0.00	26.30	0.00	28.09	0.00	35.35	0.00	20,640.62	0.09	0.09
CULBERSON	0.74	0.00	0.00	0.00	0.00	0.00	0.74	0.00	21.17	0.00	21.17	0.00	0.00
MASON	3.22	0.00	0.00	0.00	0.00	0.00	3.22	0.00	43.49	0.00	43.49	0.00	0.00
PECOS	6.12	0.00	0.00	0.00	3.01	0.00	9.13	0.01	104.77	0.00	2,463.05	0.01	0.02
RAINS	2.30	0.00	0.00	0.00	0.00	0.00	2.30	0.00	33.76	0.00	33.76	0.00	0.00
LAVACA	14.04	0.00	0.00	0.00	25.96	0.00	40.00	0.00	190.71	0.00	20,530.87	0.09	0.09
PALO PINTO	8.95	0.26	0.00	0.49	6.53	0.11	15.48	0.86	175.02	0.00	348.85	0.00	0.86
KIMBLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MADISON	27.21	0.00	0.00	0.00	0.00	0.00	27.21	0.00	372.89	0.00	372.89	0.00	0.00
ARCHER	4.30	0.00	0.00	0.00	0.00	0.00	4.30	0.00	96.25	0.00	96.25	0.00	0.00
REFUGIO	8.47	0.00	0.00	0.00	0.00	0.00	8.47	0.00	112.08	0.00	112.08	0.00	0.00
LIMESTONE	0.89	0.00	0.00	0.00	0.00	0.00	0.89	0.00	17.67	0.00	17.67	0.00	0.00
CLAY	1.07	0.00	0.00	0.00	0.00	0.00	1.07	0.00	24.06	0.00	24.06	0.00	0.00
BEE	7.62	0.00	0.00	0.00	15.05	0.00	22.67	0.00	100.87	0.00	11,892.27	0.05	0.05
MARTIN	4.04	0.00	0.00	0.00	48.94	0.00	52.98	0.00	79.13	0.00	1,159.62	0.01	0.01
GONZALES	0.87	0.00	0.00	0.00	3.76	0.00	4.63	0.00	10.85	0.00	2,958.70	0.01	0.01
BURLESON	28.01	0.00	0.00	0.00	0.00	0.00	28.01	0.00	383.45	0.00	383.45	0.00	0.00
KARNES	47.87	0.00	0.00	0.00	0.00	0.00	47.87	0.00	649.69	0.00	649.69	0.00	0.00
KLEBERG	16.98	0.16	0.00	0.00	0.00	0.00	78.62	0.00	184.42	0.00	184.42	0.00	0.00
BREWSTER	7.14	0.00	15.68	0.00	8.28	0.00	31.09	0.00	263.77	0.00	1,840.95	0.01	0.01
WINKLER	2.02	0.00	0.00	0.00	9.39	0.00	11.41	0.00	36.57	0.00	289.64	0.00	0.00
FRANKLIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YOUNG	26.63	0.52	0.00	0.96	1.43	0.22	30.26	1.70	363.95	0.00	1,684.14	0.01	1.70
HOUSTON	4.01	0.00	0.00	0.00	0.00	0.00	4.01	0.00	72.62	0.00	72.62	0.00	0.00
SCHURRY	42.13	0.16	118.26	0.00	0.00	0.00	160.44	0.00	4,620.29	0.02	4,620.29	0.02	0.02
BOSQUE	1.78	0.00	0.00	0.30	0.00	0.07	1.78	0.53	35.35	0.00	35.35	0.00	0.53
COMANCHE	0.89	0.00	0.00	0.00	0.00	0.00	0.89	0.00	17.67	0.00	17.67	0.00	0.00
BRISCOE	8.83	0.00	0.00	0.00	0.00	0.00	8.83	0.00	270.66	0.00	270.66	0.00	0.00
CONCHO	1.02	0.00	0.00	0.00	0.00	0.00	1.02	0.00	17.46	0.00	17.46	0.00	0.00
DAVALA	5.51	0.00	0.00	0.00	0.00	0.00	5.51	0.00	55.76	0.00	55.76	0.00	0.00
NOLAN	0.89	0.03	0.00	0.06	10.16	0.01	11.15	0.01	19.45	0.00	7,978.44	0.04	0.13
BROOKS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ROBERTSON	17.61	0.27	0.00	0.54	0.00	0.14	17.61	0.96	241.15	0.00	241.15	0.00	0.96
LIVE OAK	11.85	0.00	0.00	0.00	22.47	0.00	34.32	0.00	119.67	0.00	17,229.72	0.08	0.08
HAMILTON	1.78	0.00	0.00	0.00	0.00	0.00	1.78	0.00	35.35	0.00	35.35	0.00	0.00
JONES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
REGAN	2.01	0.00	0.00	0.00	0.00	0.00	2.01	0.00	40.21	0.00	40.21	0.00	0.00
WARD	16.10	0.20	0.00	0.39	0.00	0.06	16.10	0.67	197.84	0.00	197.84	0.00	0.67
RED RIVER	5.97	0.00	0.00	0.00	0.00	0.00	5.97	0.00	126.38	0.00	126.38	0.00	0.00
HASKELL	1.99	0.00	0.00	0.00	0.00	0.00	1.99	0.00	38.89	0.00	38.89	0.00	0.00
HOWARD	15.15	0.13	0.00	0.26	23.46	0.05	38.61	0.44	296.75	0.00	18,003.27	0.08	0.52
SAN SABA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JACK	9.94	0.22	0.00	0.42	15.65	0.09	25.60	0.73	194.47	0.00	12,457.52	0.06	0.79
STEPHENS	2.98	0.00	0.00	0.00	0.00	0.00	2.98	0.00	58.34	0.00	58.34	0.00	0.00
RUNNELS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
REEVES	2.02	0.00	0.00	0.00	3.76	0.00	5.78	0.00	39.57	0.00	2,987.42	0.01	0.01
DE WITT	3.39	0.00	0.00	0.00	0.00	0.00	3.39	0.00	44.83	0.00	44.83	0.00	0.00
CHILDRESS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CROSBY	6.62	0.00	0.00	0.00	0.00	0.00	6.62	0.00	475.84	0.00	475.84	0.00	0.00
DAWSON	9.98	0.00	0.00	0.00	12.47	0.00	22.45	0.00	700.90	0.00	2,448.06	0.01	0.01
MITCHELL	3.98	0.03	0.00	0.06	0.00	0.01	3.98	0.10	77.79	0.00	77.79	0.00	0.10
WILBARGER	0.00	1.31	0.00	2.44	0.26	0.54	0.26	4.29	286.35	0.00	286.35	0.00	4.29
COLEMAN	0.99	0.00	0.00	0.00	0.00	0.00	0.99	0.00	19.45	0.00	19.45	0.00	0.00
UPTON	7.02	0.00	0.00	0.00	15.80	0.00	22.83	0.01	140.74	0.00	12,521.71	0.06	0.07
COKE	1.02	0.00	0.00	0.00	0.00	0.00	1.02	0.00	17.70	0.00	17.70	0.00	0.00
CROCKETT	19.37	0.00	0.00	0.00	0.00	0.00	19.37	0.00	331.77	0.00	331.77	0.00	0.00
HARDEMAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BANDERA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAYLOR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COTTLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CRANE	4.01	0.00	0.00	0.00	0.00	0.00	4.01	0.00	80.42	0.00	80.42	0.00	0.00
DELTA	4.59	0.00	0.00	0.00	0.00	0.00	4.59	0.00	67.52	0.00	67.52	0.00	0.00
DICKENS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DUVAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EASTLAND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EDWARDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FISHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FOARD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GLASSCOCK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GOLIAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HUDSPETH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IRION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JEFF DAVIS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KENEDY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KINNEY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KNOX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LA SALLE	3.94	196.51	0.00	0.00	0.00	0.00	200.44	0.00	99.53	0.00	99.53	0.00	0.00
LEON													

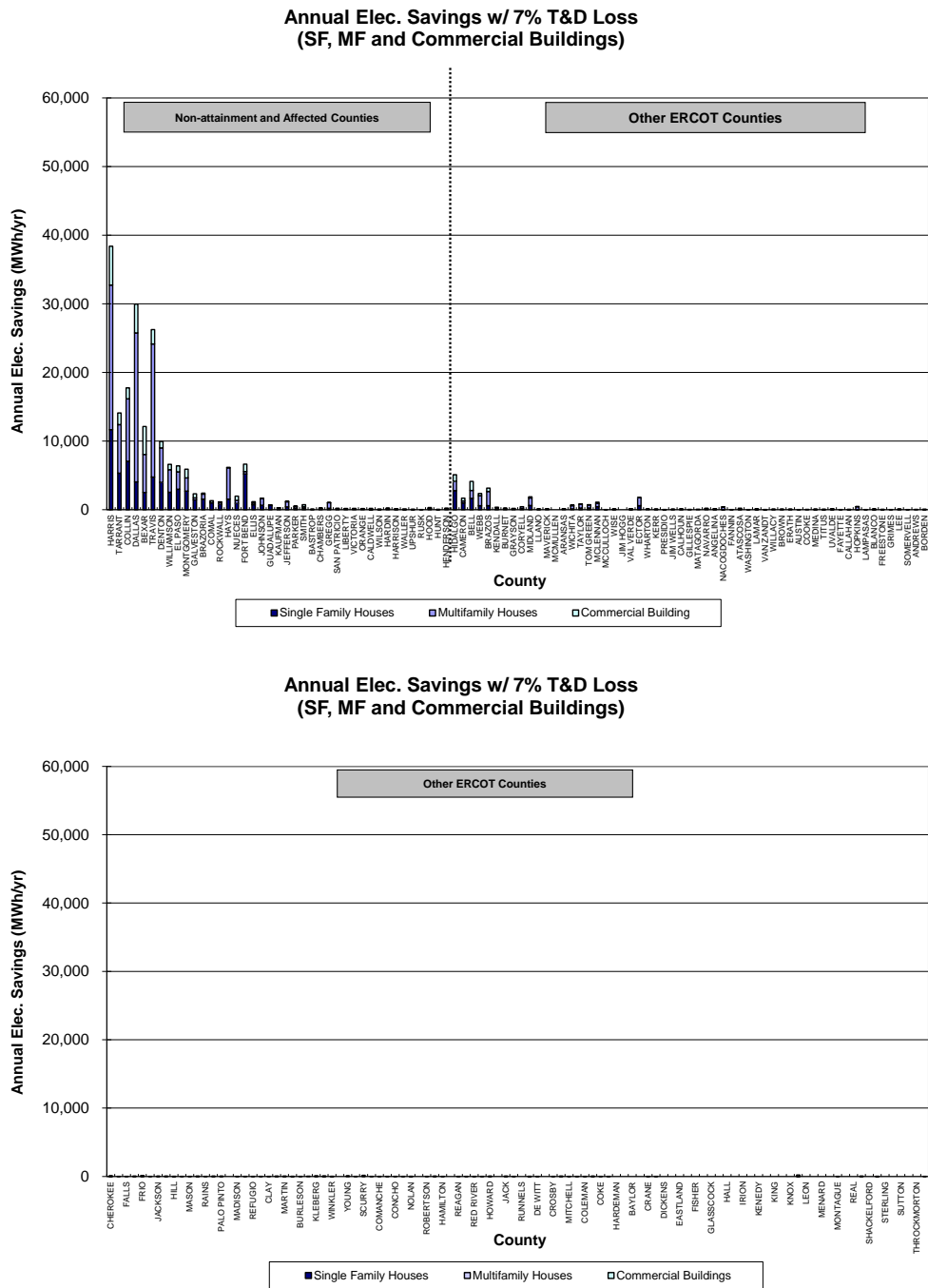


Figure 57: 2012 Annual Electricity Reductions from the 2006 IECC for Single-family and Multi-family Residences and the ASHRAE Standard 90.1-2007 for Commercial Buildings by County



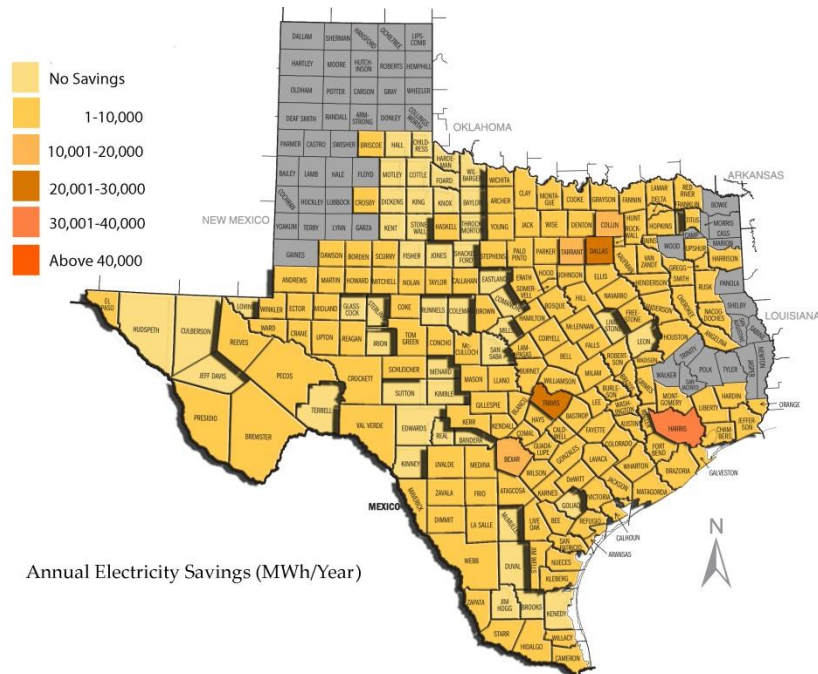


Figure 58: 2012 Annual Electricity Reductions from the 2006 IECC for Single-family and Multi-family Residences and the ASHRAE Standard 90.1-2007 for Commercial Buildings by County



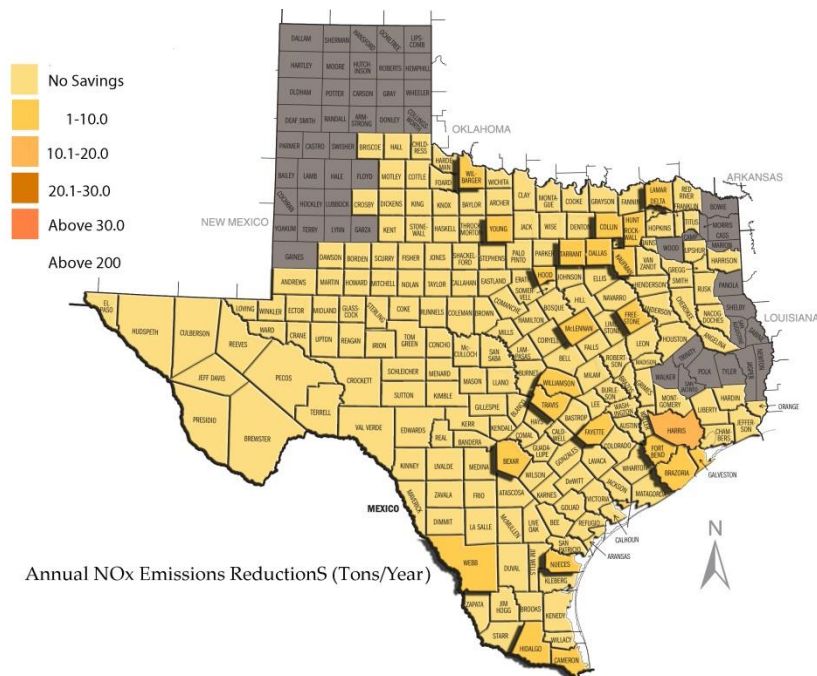


Figure 60: 2012 Annual NOx Reductions from Electricity and Natural Gas Savings Due to the 2006 IECC for Single-family and Multi-family Residences and the ASHRAE Standard 90.1-2007 for Commercial Buildings by County (using 2010 eGRID)

## 5. Calculation of Integrated NO<sub>x</sub> Emissions Reductions from Multiple State Agencies Participating in the Texas Emissions Reduction Plan (TERP)

### 5.1 Background

In January 2005, the Laboratory was asked by the Texas Commission on Environmental Quality (TCEQ) to develop a method by which the NO<sub>x</sub> emissions savings from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 could be reported in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimates from all projects projected through 2020 for both the annual and Ozone Season Day (OSD) NO<sub>x</sub> reductions. The NO<sub>x</sub> emissions reduction from all these programs were calculated using estimated emissions factors for 2010 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose. The different programs included in this 2012 integrated analysis are:

- ESL Single-family new construction
- ESL Multi-family new construction
- ESL Commercial new construction
- PUC Senate Bill 7 Program
- SECO Senate Bill 5 Program
- Electricity generated by wind farms in Texas (ERCOT)<sup>29</sup>
- SEER 13 upgrades to Single-family and Multi-family residences

*The Laboratory's single-family and multi-family programs* include the energy savings obtained by new built residences in Texas. The baseline to estimate energy savings uses the published data on residential construction characteristics by the 2008 National Association of Home Builders (NAHB 2008) based on the IECC 2006 building code (ICC 2006). Annual electricity savings (MWh) are obtained from the Laboratory's Annual Reports to the TCEQ (Haberl et al., 2002 - 2012).

*The Laboratory's commercial program* includes the energy savings attained by new commercial buildings in Texas, including office, apartment, healthcare, education, retail, food and lodging buildings as defined by Dodge types (Dodge 2011). Energy savings were estimated from code compliant buildings (ASHRAE standard 90.1-2007) against pre-code buildings (ASHRAE standard 90.1-2004) using EUI's from the USDOE report and building square footage provided in the Dodge data (Dodge 2011).

*The Texas Public Utility Commission's (PUC) Senate Bill 7 program* include the energy efficiency programs implemented by electric utilities under the Public Utility Regulatory Act §39.905 (PUC 2013). The PUC regulated energy efficiency program was adopted pursuant to 1999 legislation (SB 7) and subsequent legislation in 2001 (SB 5), 2007 (HB 3693), and 2011 (SB 1125). The energy efficiency measures include high efficiency HVAC equipment, variable speed drives, increased insulation levels, infiltration reduction, duct sealing, Energy Star Homes, etc. Annual electricity savings according to the utilities were reported for the different programs completed in the years 2001 through 2012.

*The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs* that are directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers. For the 2012 reporting year SECO submitted annual energy savings values for projects funded by SECO and by Energy Service projects.

*The Electric Reliability Council of Texas (ERCOT) electricity production from currently installed green power generation (wind)* in Texas is reported. Projections through 2013 include planned projects by ERCOT, annual growth factors beyond 2013 comply with the Legislative requirements. Actual measured electricity production for 2001 through 2012, were included.

<sup>29</sup> ERCOT is the Electric Reliability Council of Texas.

Finally, NO<sub>x</sub> emissions reductions from *the installation of SEER 13 air conditioners in existing residences* are also reported.

## 5.2 Description of the Analysis Method

Annual and Ozone Season Day (OSD) NO<sub>x</sub> emissions reduction were calculated for 2012 and integrated from 2009 to 2020 using several factors to discount the potential savings. These factors include an annual degradation factor, a transmission and distribution factor, a discount factor, and growth factors as shown in Table 27 and are described as follows:

*Annual degradation factor:* This factor was used to account for an assumed decrease in the performance of the measures installed as the equipment wears down and degrades. With the exception of electricity generated from wind, an annual degradation factor of 2% was used for ESL Single-family, Multi-family, and commercial programs and an annual degradation factor of 5% was used for all other programs<sup>30</sup>. The value of the 5% degradation factor was taken from a study by Kats et al. (1996).

*Transmission and distribution loss:* This factor adjusts the reported savings to account for the loss in energy resulting from the transmission and distribution of the power from the electricity producers to the electricity consumers. For this calculation, the energy savings reported at the consumer level are increased by 7% to give credit for the actual power produced that is lost in the transmission and distribution system on its way to the customer. In the case of electricity generated by wind, the T&D losses were assumed to cancel out since wind energy is displacing power produced by conventional power plants; therefore, there is no net increase or decrease in T&D losses.

*Initial discount factor:* This factor was used to discount the reported savings for any inaccuracies in the assumptions and methods employed in the calculation procedures. For the Laboratory's single, multi-family and commercial program, the discount factor was assumed to be 20%. For PUC's Senate Bill 7 program and electricity from wind, the discount factor was taken as 10%. For the savings in the SECO program, the discount factor was 60%. In addition, the discount factor for SEER 13 single-family and SEER 13 multi-family program was 20%.

*Growth factor:* The growth factors shown in Table 26 were used to account for several different factors. Growth factors for single-family (3.3%), multi-family residential (1.5%), and commercial (3.3%) construction are projections based on the average growth rate for these housing types from recent U.S. Census data for Texas. Growth factor for wind energy (3.9%) is a linear projection based on the installed wind power capacity for 2009 through 2012 from the Texas Public Utilities Commission. No growth was assumed for PUC programs, SECO, and SEER 13 entries.

Figure 61 shows the overall information flow that was used to calculate the NO<sub>x</sub> emissions savings from the annual and Ozone Season Day (OSD) electricity savings (MWh) from all programs. For the Laboratory's single-family and multi-family code-implementation programs, the annual and OSD were calculated from DOE-2 hourly simulation models<sup>31</sup>. The base case is taken as the average characteristics of single- and multi-family residences for Texas published by the National Association of Home Builders for 2008 (NAHB 2008). The annual electricity savings from PUC programs were calculated using demand savings tables created for the utilities incentive programs by Frontier Associates in Austin, Texas (PUC 2013). The OSD consumption is the average daily consumption for the period between July 15 and September 15.

<sup>30</sup> A degradation of 5% per year would accumulate as a 5%, 10%, 15%...etc, degradation in performance. Although the assumption of this high level of degradation may not actually occur, it was chosen as a conservative estimate. For wind energy, a degradation factor of 0% was used. The choice of a 0% degradation factor for wind is based on two year's of analysis of measured wind data from all Texas wind farms that shows no degradation, on average, for a two year period after the wind farms became operational.

<sup>31</sup> These values are based on a performance analysis as defined by Chapter 4 of IECC 2006. This analysis is discussed in the Laboratory's annual reports to the TCEQ.



The SECO electricity savings were submitted as annual savings by project<sup>32</sup>. A description of the measures completed for the project was also submitted for information purposes. The electricity production from wind farms in Texas was from the actual on-site metered data measured at 15-minute intervals.

Integration of the savings from the different programs into a uniform format allowed for creditable NOx emissions to be evaluated using different criteria as shown in Table 26. These include evaluation across programs, evaluation across individual counties by program, evaluation by SIP area, evaluation for all ERCOT counties except Houston/Galveston, and evaluation within a 200 km radius of Dallas/Ft. Worth.

### 5.3 Calculation Procedure

The electricity savings in this report was estimated based on the baseline year of 2008. In addition, the emissions estimation throughout this report was based on the 2010 eGrid database which is using the four different Congestion Management (CM) zones: Houston, North, West, and South. This report calculates the OSD emissions reductions by dividing the annual emissions reductions with 365 since the 2010 eGrid estimates the annual emissions only. However, the OSD emissions reduction from the Electricity Generated by Wind Farms was estimated by actual measured data.

*ESL Single-family and Multi-family.* The calculation of the annual electricity savings reported for the years 2002 through 2012 included the savings from code-compliant new housing in all 41 non-attainment and affected counties as reported in the Laboratory's annual report submitted by the Laboratory to the Texas Commission of Environmental Quality (TCEQ). From 2009 to 2012, based on year 2008, the annual electricity savings were calculated for new residential construction in all the counties in ERCOT region, which includes the 41 non-attainment and affected counties. These savings were then tabulated by county and program. Using the calculated values through 2012, savings were then projected to 2020 by incorporating the different adjustment factors mentioned above.

In these calculations, it was assumed that the same amount of electricity savings from the code-complaint construction would be achieved for each year after 2012 through 2020<sup>33</sup>. The projected energy savings through 2020, according to county, were then divided into the CM zones in the 2010 eGRID. To determine which CM zone was to be used, or in counties with multiple CM zone, the allocation to each CM zone by county was obtained from CM zone's listing published in the Laboratory's 2010 annual report<sup>34</sup>.

For the 2012 annual NOx emissions calculations, the US EPA's 2010 eGRID were used. An example of the eGRID spreadsheet<sup>35</sup> is given in the Table 28. The total electricity savings for each CM zone were used to calculate the NOx emissions reduction for each of the different counties using the emissions factors contained in eGRID. Similar calculations were performed for each year for which the analysis was required.

*ESL-Commercial Buildings.* The annual electricity savings for 2004 through 2012 for commercial buildings were obtained from the annual reports for 2004 through 2012 submitted by the Laboratory to TCEQ<sup>36</sup>. From 2009 to 2012, based on year 2008, the annual electricity savings were also calculated for new commercial construction by county. Using the calculated values through 2012, savings were then projected to 2020 by incorporating the different adjustment factors mentioned above<sup>37</sup>. In the projected annual electricity savings, it was assumed that the same 2012 amount of electricity savings would be achieved for each year through 2020. Similarly to the single family

<sup>32</sup> The reporting requirements to the SECO did not require energy savings by project type, although for selected sites, energy savings by project type was available.

<sup>33</sup> This would include the appropriate discount and degradation factors for each year.

<sup>34</sup> Haberl et al., 2010, pp. 265.

<sup>35</sup> To use this spreadsheet electricity savings for each eGrid zone is entered in the bottom row of the spreadsheet (MWh). The spreadsheet then allocates the MWh of electricity savings according to the counties (blue columns) where the CM zone owned and operated a power plant. Totals for all CM zones are then listed on the far right columns (white columns). Similar spreadsheets for the 2010 eGRID exist for SOx and CO2.

<sup>36</sup> These savings include new construction in office, education, retail, food, lodging and warehouse construction as defined by Dodge building type (Dodge 2011), using energy savings from the US DOE's report (USDOE 2011), and data from CBECS (1995 - 2003).

<sup>37</sup> This also includes the appropriate discount and degradation factors for each year.

calculations, the projected energy saving numbers through 2020, by county, were allocated into the appropriate CM zones

*PUC-Senate Bill 7.* For the PUC Senate Bill 7 program savings, the annual electricity savings for 2001 through 2012 were obtained from the Public Utilities Commission. Using these values savings were projected through 2020 by incorporating the different adjustment factors mentioned above. Similar savings were assumed for each year after 2012 until 2020. The 2010 annual eGRID was also used to calculate the NOx emissions savings for the PUC-Senate Bill 7 program. The total electricity savings for each CM zone was used to calculate the NOx emissions reduction for each county using the emissions factors contained in the US EPA's eGRID spreadsheet. The integrated NOx emissions reduction for each county was then calculated.

*SECO Savings.* The annual electricity savings from energy conservation projects reported by political subdivisions for 39 counties through 2012 were obtained from the State Energy Conservation Office. These submittals included information gathered from SECO's website<sup>38</sup> and paper submittals<sup>39</sup>. The annual and average day electricity values were then summarized according to county and program. Using the actual reported numbers for 2007 through 2012, savings through 2020 were projected using the different adjustment factors mentioned above. In a similar fashion to the previous programs, it was assumed that the same amount of electricity savings will be achieved for each year through 2020. The 2010 annual eGRID were then used to calculate the NOx emissions savings for the SECO program.

*Electricity Generated by Wind Farms.* The measured electricity production from all the wind farms in Texas for 2001 through 2012 was obtained from the Energy Reliability Council of Texas (ERCOT). To obtain the annual production, the 15-minute data were summed for the 12 months. Using the reported numbers for 2012, savings through 2020 were projected incorporating the different adjustment factors mentioned above. The 2007 annual eGRID were then used to calculate the NOx emissions reduction for the electricity generated by Texas' wind farms<sup>40</sup>. The total electricity savings for each CM zone was used to calculate the NOx emissions reduction for each of the different counties.

*SEER 13 Single-Family and Multi-Family.* In January of 2006, Federal regulations mandated that the minimum efficiency for residential air conditioners be increased to SEER 13 from the previous SEER 10. Although the electricity savings from new construction reflected this change in values, the annual and OSD electricity savings from the replacement of the air conditioning units by air conditioners with an efficiency of SEER 13 in existing residences needed to be calculated.

In the 2012 report to the TCEQ, the annual and OSD electricity savings for all the counties in ERCOT region as well as the 41 non-attainment and affected counties were calculated. Using the numbers for 2006, the savings after 2006 until 2020 were projected by incorporating the appropriate adjustment factors<sup>41</sup>. In this analysis, it was assumed that an equal number of existing houses had their air conditioners replaced, as reported for 2006, by the air conditioner manufacturers. This replacement rate continued until all the existing air conditioner stock was replaced with SEER 13 air conditioners. The total electricity savings for each PCA were used to calculate the NOx emissions reduction for each of the different county using the emissions factors contained in the 2010 eGRID. Integrated NOx emissions reduction for each county by SIP area was also calculated.

<sup>38</sup> This web site was developed for SECO by the Laboratory, at the request of the TCEQ.

<sup>39</sup> In these submittals, there were several municipalities whose electricity or natural consumption increased in 2004 as compared to 2001, which caused the reported savings from these municipalities to be negative. Since no additional information was reported from these projects that might have indicated what the cause of this was, it was assumed that the energy conservation projects were working as designed, but that other factors had changed the energy consumption. Therefore, in the final values of electricity savings from the political subdivisions that reported to SECO for the calculation of annual NOx reductions, the negative savings were omitted.

<sup>40</sup> This credited the electricity generated by the wind farm to the utility that either owned the wind farm or was associated with the wind farm owner.

<sup>41</sup> Additional details about this calculation are contained in the Laboratory's 2006 Annual Report to the TCEQ, available at the Senate Bill 5 web site "eslsb5.tamu.edu".

## 5.4 Results

The total integrated annual and OSD electricity savings for all the different programs in the integrated format was calculated using the adjustment factors shown in Table 27 for 2009 through 2020 as shown in Table 29. Annual and OSD NOx emissions reduction from the electricity savings (presented in Table 1) for all the programs in the integrated format is shown in Table 30.

In 2012, the total integrated annual savings from all programs is 16,413,917 MWh/year. The integrated annual electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 498,883 MWh/year (3.0% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program is 1,831,318 MWh/year (11.2%),
- Savings from SECO's Senate Bill 5 program is 714,891 MWh/year (4.4%),
- Electricity savings from green power purchases (wind) is 13,049,580 MWh/year (79.5%), and
- Savings from residential air conditioner retrofits<sup>42</sup> is 319,244 MWh/year (1.9%).

In 2012, the total integrated OSD savings from all programs is 44,366 MWh/day, which would be a 1,849 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 1,852 MWh/day (4.2%),
- Savings from the PUC's Senate Bill 7 programs is 5,017 MWh/day (11.3%),
- Savings from SECO's Senate Bill 5 program is 1,959 MWh/day (4.4%),
- Electricity savings from green power purchases (wind) are 33,273 MWh/day (75.0%), and
- Savings from residential air conditioner retrofits are 2,264 MWh/day (5.1%).

By 2013, the total integrated annual savings from all programs is 17,661,268 MWh/year. The integrated annual electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 682,701 MWh/year (3.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program is 2,205,082 MWh/year (12.5%),
- Savings from SECO's Senate Bill 5 program is 909,903 MWh/year (5.2%),
- Electricity savings from green power purchases (wind) is 13,560,301 MWh/year (76.8%), and
- Savings from residential air conditioner retrofits is 303,282 MWh/year (1.7%).

By 2013, the total integrated OSD savings from all programs is 47,607 MWh/day, which would be a 1,984 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction is 2,346 MWh/day (4.9%),
- Savings from the PUC's Senate Bill 7 programs is 6,041 MWh/day (12.7%),
- Savings from SECO's Senate Bill 5 program is 2,493 MWh/day (5.2%),
- Electricity savings from green power purchases (wind) are 34,575 MWh/day (72.6%), and
- Savings from residential air conditioner retrofits are 2,151 MWh/day (4.5%).

In 2012, the total integrated annual NOx emissions reduction from all programs is 4,609 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is:

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<sup>42</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- NOx emissions reduction from code-compliant residential and commercial construction is 126 tons-NOx/year (2.7% of the total NOx savings),
- NOx emissions reduction from the PUC's Senate Bill 7 programs is 522 tons-NOx/year (11.3%),
- NOx emissions reduction from SECO's Senate Bill 5 program is 221 tons-NOx/year (4.8%),
- NOx emissions reduction from green power purchases (wind) is 3,665 tons-NOx/year (79.5%), and
- NOx emissions reduction from residential air conditioner retrofits is 75 tons-NOx/year (1.6%).

In 2012, the total integrated OSD NOx emissions reduction from all programs is 12.35 tons-NOx/day. The integrated OSD NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction is 0.47 tons-NOx/day (3.8%),
- NOx emissions reduction from the PUC's Senate Bill 7 programs is 1.43 tons-NOx/day (11.6%),
- NOx emissions reduction from SECO's Senate Bill 5 program is 0.60 tons-NOx/day (4.9%),
- NOx emissions reduction from green power purchases (wind) are 9.32 tons-NOx/day (75.5%), and
- NOx emissions reduction from residential air conditioner retrofits are 0.53 tons-NOx/day (4.3%).

By 2013, the total integrated annual NOx emissions reduction from all programs will be 4,959 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction will be 172 tons-NOx/year (3.5% of the total NOx savings),
- NOx emissions reduction from the PUC's Senate Bill 7 programs will be 629 tons-NOx/year (12.7%),
- NOx emissions reduction from SECO's Senate Bill 5 program will be 277 tons-NOx/year (5.6%),
- NOx emissions reduction from green power purchases (wind) will be 3,809 tons-NOx/year (76.8%), and
- NOx emissions reduction from residential air conditioner retrofits will be 71 tons-NOx/year (1.4%).

By 2013, the total integrated OSD NOx emissions reduction from all programs is 13.26 tons-NOx/day. The integrated OSD NOx emissions reduction from all the different programs is:

- NOx emissions reduction from code-compliant residential and commercial construction will be 0.59 tons-NOx/day (4.5%),
- NOx emissions reduction from the PUC's Senate Bill 7 programs will be 1.72 tons-NOx/day (13.0%),
- NOx emissions reduction from SECO's Senate Bill 5 program will be 0.76 tons-NOx/day (5.7%),
- NOx emissions reduction from green power purchases (wind) will be 9.69 tons-NOx/day (73.1%), and
- NOx emissions reduction from residential air conditioner retrofits will be 0.50 tons-NOx/day (3.8%).

Table 27: Final Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs

	ESL- Single Family	ESL- Multi Family	ESL- Commercial	PUC (SB7)	SECO	Wind-ERCOT	SEER13 Single Family	SEER13 Multi Family
Annual Degradation Factor	2.0%	2.0%	2.0%	5.0%	5.0%	0.0%	5.0%	5.0%
T&D Loss	7.0%	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor	20.0%	20.0%	20.0%	10.0%	60.0%	10.0%	20.0%	20.0%
Growth Factor	3.3%	1.5%	3.3%	0.0%	0.0%	3.9%	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No <sup>1</sup>	Yes	Yes



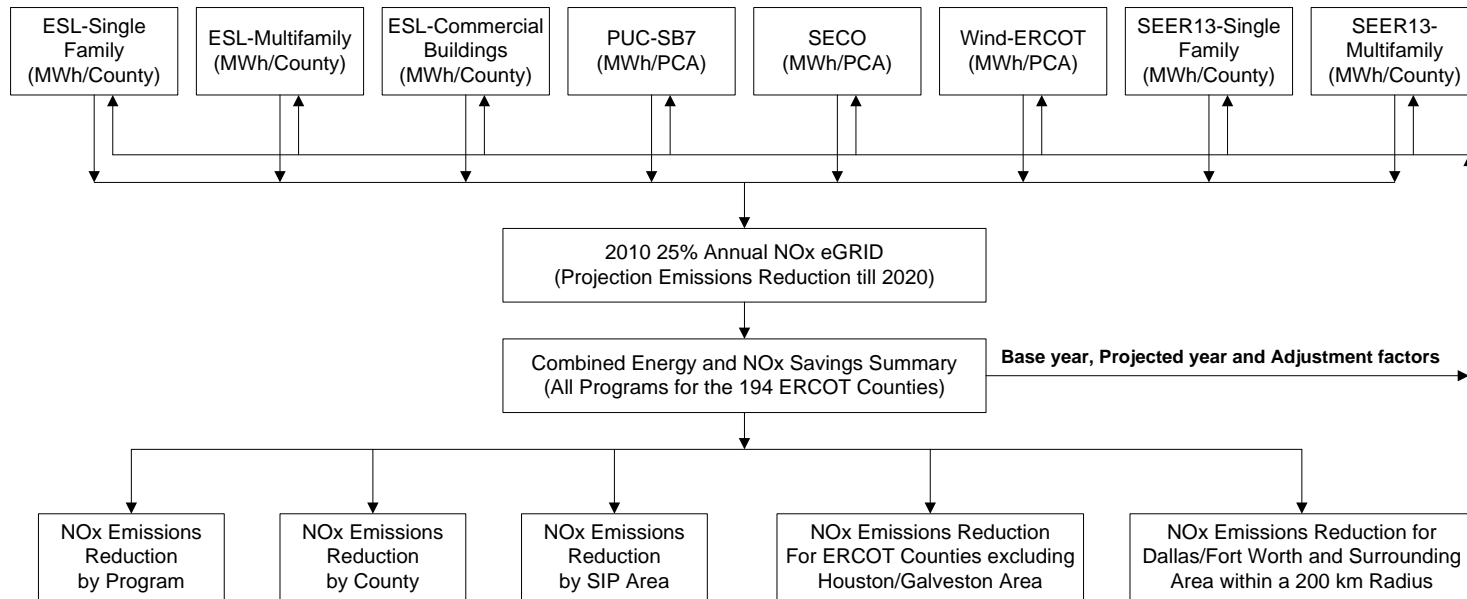


Figure 61: Process Flow Diagram of the NOx Emissions Reduction Calculations

Table 28: Example of NOx Emissions Reduction Calculations using 2010 eGRID

Area	County	CM Zones				Total Nox Reductions (lbs)	Total Nox Reductions (Tons)					
		H	N	W	S							
Houston- Galveston Area	Brazoria	0.0562032	347.6943	0.0000071	0.0710	0.0000003	0.0005265	3.8055	351.57	0.18		
	Chambers	0.0204500	126.5115	0.0000026	0.0258	0.0000001	0.0001916	1.3847	127.92	0.06		
	Fort Bend	0.0313463	193.9202	0.0000040	0.0396	0.0000002	0.0001937	2.1224	196.08	0.10		
	Galveston	0.0226620	140.1955	0.0000029	0.0286	0.0000001	0.0001213	1.5344	141.76	0.07		
	Harris	0.1486911	919.8596	0.000189	0.1877	0.0000009	0.0006	0.0013930	10.0678	0.47		
	Liberty	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00		
	Montgomery	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00		
	Waller	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00		
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00		
	Jefferson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00		
Dallas/ Fort Worth Area	Orange	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00		
	Collin	0.0012932	8.0000	0.0079329	78.9444	0.0003832	0.2345	0.0008089	0.5849	87.76	0.04	
	Dallas	0.0024826	15.3584	0.0152295	151.5565	0.0007356	0.4503	0.0001554	1.1230	168.49	0.08	
	Denton	0.0001267	0.7836	0.0007770	7.7325	0.0000375	0.0230	0.0000079	0.0573	8.60	0.00	
	Tarrant	0.0004742	2.9335	0.0029089	28.9478	0.0001405	0.0860	0.0000297	0.2145	32.18	0.02	
	Ellis	0.0029920	18.5096	0.0183544	182.6530	0.0008865	0.5426	0.0001873	1.3534	203.06	0.10	
	Johnson	0.0007256	4.4888	0.0044512	44.2958	0.0002150	0.1316	0.0000454	0.3282	49.24	0.02	
	Kaufman	0.0009718	36.9441	0.0063433	364.5651	0.0017695	1.0831	0.0003738	2.7012	405.29	0.20	
	Parker	0.0000012	0.0076	0.0000075	0.0751	0.0000004	0.0002	0.0000001	0.0006	0.08	0.00	
	Rockwall	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Henderson	0.0006908	4.2734	0.0042376	42.1700	0.0002047	0.1253	0.0000432	0.3125	46.88	0.02	
	Hood	0.0005071	31.4088	0.0311454	309.9429	0.0015044	0.9208	0.0003178	2.2965	344.57	0.17	
	Hunt	0.0088463	54.7268	0.0047066	46.8380	0.0002273	0.1391	0.0052823	471.8144	573.52	0.29	
	E Paso Area	E Paso	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	
	San Antonio Area	Bexar	0.0138906	85.9325	0.0009368	9.3227	0.0000452	0.0277	0.1109355	801.7639	897.05	0.45
Cornal		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Guadalupe		0.0032029	19.8143	0.0002160	2.1496	0.0000104	0.0064	0.0255795	184.8703	206.84	0.10	
Austin Area	Wilson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Bastrop	0.0033782	20.8990	0.0002278	2.2673	0.0000110	0.0067	0.0269798	194.9906	218.16	0.11	
	Caldwell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Hays	0.0008331	5.1541	0.0000562	0.5592	0.0000027	0.0017	0.0066537	48.0881	53.80	0.03	
	Travis	0.0051785	32.0364	0.0003493	3.4756	0.0000169	0.0103	0.0413577	298.9044	334.43	0.17	
	Williamson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	North East Texas Area	Gregg	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Harrison	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Rusk	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Smith	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Upshur	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Nueces	0.0128578	79.5431	0.0008672	8.6295	0.0000419	0.0256	0.1026870	742.1493	830.35	0.42
	Corpus Christi Area	San Patricio	0.0015100	9.3411	0.0001018	1.0134	0.0000049	0.0030	0.0120591	87.1543	97.51	0.05
	Victoria Area	Victoria	0.0021192	13.1099	0.0001429	1.4223	0.0000069	0.0042	0.0169244	122.3174	136.85	0.07
		Andrews	0.0000037	0.0232	0.0000230	0.2286	0.0000003	0.0000	0.0000002	0.0017	2.64	0.00
Angelina		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Boque		0.0022204	13.7364	0.0136212	135.5508	0.0006579	0.4027	0.0001380	1.0044	150.69	0.08	
Brazos		0.0024089	14.9022	0.0112305	111.7603	0.0005425	0.3320	0.0047829	34.5675	161.56	0.08	
Calhoun		0.0009466	5.8559	0.0000638	0.6353	0.0000031	0.0019	0.0075598	54.6366	61.13	0.03	
Cameron		0.0063536	39.3060	0.0004285	4.2642	0.0000207	0.0127	0.0507425	366.7307	410.31	0.21	
Cherokee		0.0027392	16.9455	0.0168033	167.2180	0.0008116	0.4968	0.0001714	1.2390	185.90	0.09	
Coke		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Coleman		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Crockett		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Ector		0.0019215	11.8872	0.0006604	6.5715	0.0011346	55.7813	0.0146527	105.8993	180.14	0.09	
Fannin		0.0000041	0.0251	0.0000249	0.2475	0.0000012	0.0007	0.0000003	0.0018	0.28	0.00	
Fayette		0.0051867	32.0869	0.0103217	102.7160	0.0004986	0.3052	0.0283993	205.2502	340.36	0.17	
Freestone		0.0047643	29.4740	0.0292268	290.8499	0.0014117	0.8641	0.0002982	2.1551	323.34	0.16	
Frio		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Grimes		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Hardeman		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Haskell		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Hidalgo		0.0053716	33.2306	0.0003623	3.6051	0.0000175	0.0107	0.0428994	310.0466	346.89	0.17	
Howard		0.0002411	1.4916	0.0007641	7.6036	0.1283942	78.5870	0.0009490	6.8586	94.54	0.05	
Jack		0.0030783	19.0436	0.0188839	187.9227	0.0009121	0.5583	0.0001927	1.3924	208.92	0.10	
Jones		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Lamar		0.0040001	24.7464	0.0245388	244.1978	0.0011853	0.7255	0.0002504	1.8094	271.48	0.14	
Limestone		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Llano		0.0040314	24.9401	0.0002719	2.7057	0.0000131	0.0080	0.0321966	232.6946	260.35	0.13	
McLennan		0.0056576	35.0002	0.0347066	345.3824	0.0016764	1.0261	0.0003541	2.5591	383.97	0.19	
Millam		0.0012686	7.8481	0.0000656	0.6514	0.0000041	0.0025	0.0101316	73.2238	81.93	0.04	
Mitchell		0.0000311	0.1926	0.0001910	1.9003	0.0324260	19.8472	0.0000019	0.0141	21.95	0.01	
Nolan		0.0000293	0.1810	0.0001795	1.7860	0.0304745	18.6527	0.0000018	0.0132	20.63	0.01	
Palo Pinto		0.0036129	22.3510	0.0221635	220.5601	0.0010705	0.6552	0.0002261	1.6342	245.20	0.12	
Pecos	0.0000020	0.0122	0.0000121	0.1203	0.0020520	1.2560	0.0000001	0.0009	1.39	0.00		
Presidio	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00		
Red River	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00		
Robertson	0.0039506	24.4397	0.0055755	55.4842	0.0002693	0.1648	0.0246170	177.9140	258.00	0.13		
Taylor	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00		
Titus	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00		
Tom Green	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00		
Upton	0.0000025	0.0157	0.0000156	0.1553	0.0026494	1.6217	0.0000002	0.0012	1.79	0.00		
Ward	0.0001995	1.2343	0.0012239	12.1801	0.2078335	127.2099	0.0000125	0.0902	140.71	0.07		
Webb	0.0042017	25.9935	0.00002834	2.8200	0.0000137	0.0084	0.0335565	242.5231	271.34	0.14		
Wharton	0.0021095	13.0502	0.0001423	1.4158	0.0000069	0.0042	0.0168474	121.7608	136.23	0.07		
Wichita	0.0000121	0.0749	0.0000743	0.7395	0.0126190	7.7238	0.0000008	0.0055	8.54	0.00		
Wilbarger	0.0179710	111.1755	0.1102430	1097.0811	0.0053249	3.2593	0.0011247	8.1288	1219.64	0.61		
Wise	0.0010202	6.3112	0.0062583	62.2792	0.0003023	0.1850	0.0000638	0.4615	69.24	0.03		
Young	0.0071054	43.9567	0.0435880	433.7654	0.0021054	1.2886	0.0004447	3.2140	482.22	0.22		
Total		0.441501	2730.974	0.4812863	4789.5112	0.5345786	327.0227	0.6829349	4935.7718	12783.46	6.33	
Energy Savings (MWh)		6,186	9,951	612	7,227							

Table 29: Annual and OSD Electricity Savings for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	0	21,748	55,268	93,760	153,171	213,417	274,548	336,614	399,668	463,763	528,956	595,303	662,861
ESL-Multifamily (MWh)	0	50,218	94,867	167,566	262,939	357,885	452,435	546,620	640,469	734,013	827,282	920,305	1,013,111
ESL-Commercial (MWh)	0	0	25,750	54,550	82,773	111,399	140,452	169,957	199,937	230,420	261,430	292,996	325,145
PUC (SB7) (MWh)	0	538,841	976,984	1,437,883	1,831,318	2,205,082	2,560,158	2,897,479	3,217,935	3,522,368	3,811,579	4,086,330	4,347,343
SECO (MWh)	0	235,216	293,537	509,616	714,891	909,903	1,095,163	1,271,161	1,438,359	1,597,197	1,748,093	1,891,444	2,027,628
Wind-ERCOT (MWh)	0	3,273,150	8,135,429	10,995,427	13,049,580	13,560,301	14,091,009	14,642,488	15,215,550	15,811,039	16,429,835	17,072,848	17,741,026
SEER13-Single Family (MWh)	0	343,330	326,163	309,855	294,362	279,644	265,662	252,379	239,760	227,772	216,383	205,564	195,286
SEER13-Multifamily (MWh)	0	29,021	27,569	26,191	24,881	23,637	22,456	21,333	20,266	19,253	18,290	17,376	16,507
<b>Total Annual (MWh)</b>	<b>0</b>	<b>4,491,524</b>	<b>9,935,568</b>	<b>13,594,848</b>	<b>16,413,917</b>	<b>17,661,268</b>	<b>18,901,882</b>	<b>20,138,030</b>	<b>21,371,943</b>	<b>22,605,825</b>	<b>23,841,849</b>	<b>25,082,165</b>	<b>26,328,906</b>

PROGRAM	OZONE SEASON DAY - OSD												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	0	124	283	468	626	787	951	1,117	1,286	1,457	1,632	1,810	1,992
ESL-Multifamily (MWh)	0	233	460	744	999	1,254	1,508	1,760	2,012	2,263	2,514	2,764	3,013
ESL-Commercial (MWh)	0	0	71	149	227	305	385	466	548	631	716	803	891
PUC (SB7) (MWh)	0	1,476	2,677	3,939	5,017	6,041	7,014	7,938	8,816	9,650	10,443	11,195	11,911
SECO (MWh)	0	644	804	1,396	1,959	2,493	3,000	3,483	3,941	4,376	4,789	5,182	5,555
Wind-ERCOT (MWh)	0	14,246	23,054	27,654	33,273	34,575	35,929	37,335	38,796	40,314	41,892	43,532	45,235
SEER13-Single Family (MWh)	0	2,445	2,323	2,207	2,097	1,992	1,892	1,798	1,708	1,622	1,541	1,464	1,391
SEER13-Multifamily (MWh)	0	195	186	176	167	159	151	144	136	130	123	117	111
<b>Total OSD (MWh)</b>	<b>0</b>	<b>19,365</b>	<b>29,857</b>	<b>36,734</b>	<b>44,366</b>	<b>47,607</b>	<b>50,830</b>	<b>54,039</b>	<b>57,242</b>	<b>60,444</b>	<b>63,651</b>	<b>66,867</b>	<b>70,099</b>

Table 30: Annual and OSD NOx Emissions Reduction Values for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL (in tons NOx)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	0	5	14	23	38	53	68	83	99	115	131	147	164
ESL-Multifamily	0	13	24	43	67	92	117	141	166	190	214	239	263
ESL-Commercial	0	0	6	14	21	28	35	42	50	57	65	73	81
PUC (SB7)	0	151	274	409	522	629	731	828	921	1,008	1,091	1,170	1,245
SECO	0	67	99	162	221	277	330	381	429	475	518	559	599
Wind-ERCOT	0	893	2,268	3,062	3,665	3,809	3,958	4,113	4,274	4,441	4,615	4,796	4,983
SEER13-Single Family	0	81	77	73	69	66	62	59	56	53	51	48	46
SEER13-Multifamily	0	7	6	6	6	6	5	5	5	5	4	4	4
<b>Total Annual (Tons NOx)</b>	<b>0</b>	<b>1,217</b>	<b>2,769</b>	<b>3,790</b>	<b>4,609</b>	<b>4,959</b>	<b>5,307</b>	<b>5,653</b>	<b>5,999</b>	<b>6,344</b>	<b>6,690</b>	<b>7,036</b>	<b>7,384</b>

PROGRAM	OZONE SEASON DAY - OSD (in tons NOx/day)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	0.00	0.03	0.07	0.11	0.15	0.19	0.23	0.28	0.32	0.36	0.40	0.45	0.49
ESL-Multifamily	0.00	0.06	0.12	0.19	0.26	0.32	0.39	0.45	0.52	0.58	0.65	0.72	0.78
ESL-Commercial	0.00	0.00	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.22
PUC (SB7)	0.00	0.41	0.75	1.12	1.43	1.72	2.00	2.27	2.52	2.76	2.99	3.21	3.41
SECO	0.00	0.18	0.27	0.44	0.60	0.76	0.90	1.04	1.18	1.30	1.42	1.53	1.64
Wind-ERCOT	0.00	3.94	6.42	7.63	9.32	9.69	10.06	10.46	10.87	11.29	11.74	12.19	12.67
SEER13-Single Family	0.00	0.57	0.54	0.51	0.49	0.46	0.44	0.42	0.40	0.38	0.36	0.34	0.32
SEER13-Multifamily	0.00	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
<b>Total OSD (Tons NOx)</b>	<b>0.00</b>	<b>5.24</b>	<b>8.23</b>	<b>10.09</b>	<b>12.35</b>	<b>13.26</b>	<b>14.16</b>	<b>15.07</b>	<b>15.97</b>	<b>16.86</b>	<b>17.76</b>	<b>18.66</b>	<b>19.57</b>

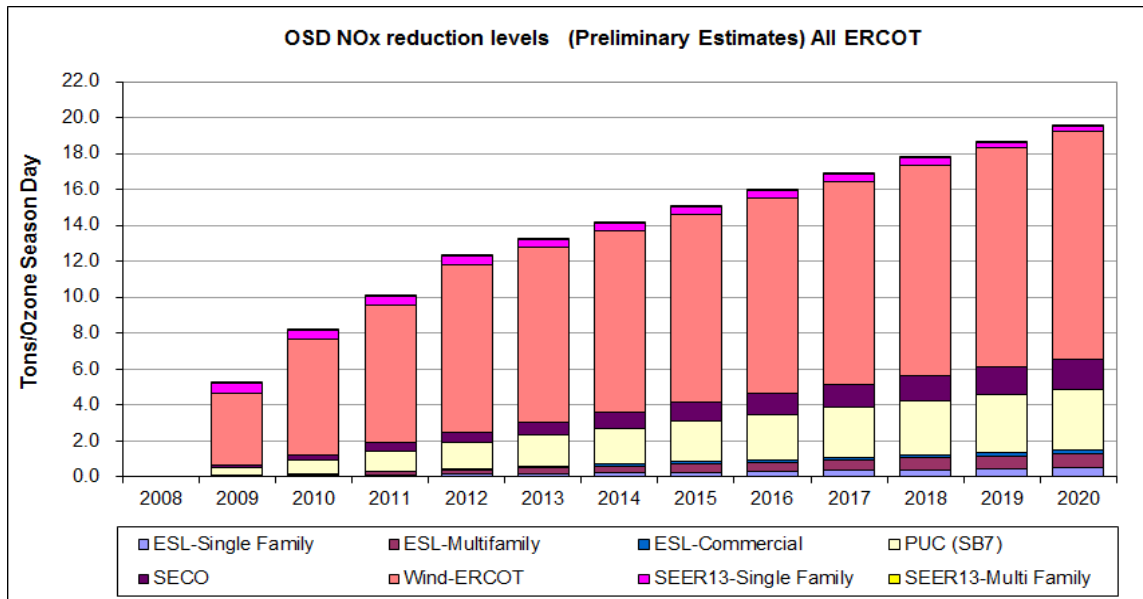


Figure 62: Integrated OSD NOx Emissions Reduction Projections through 2020 (Base Year 2008)

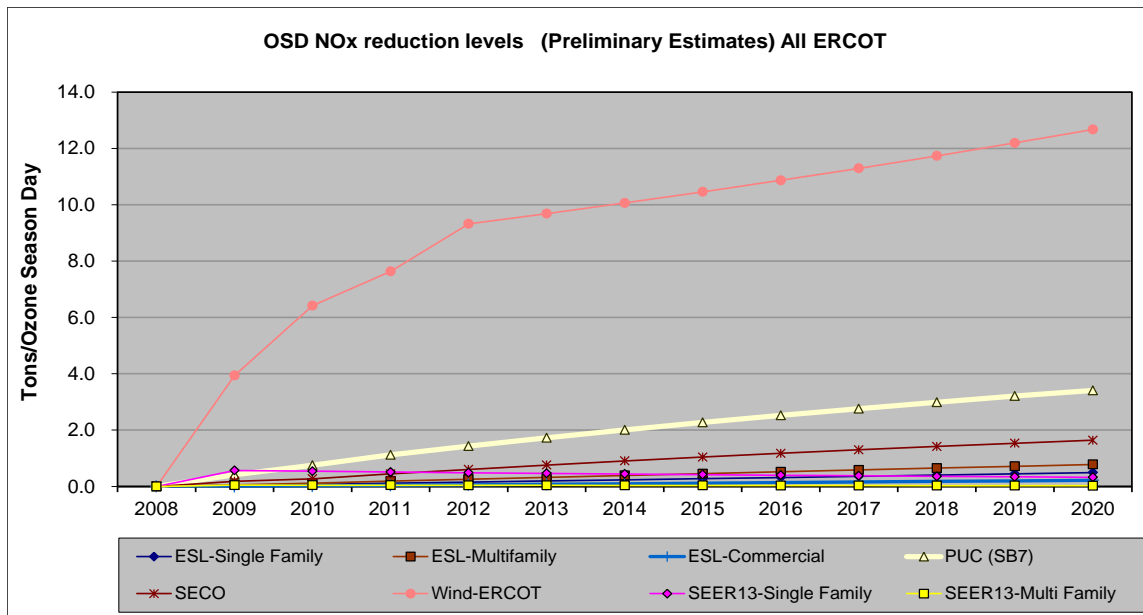


Figure 63: Integrated OSD Individual Programs NOx Emissions Reduction Projections through 2020 (Base Year 2008)

## 6. Verification of the IC3 software, AIM program and: eCALC calculator.

As part of the analysis effort, verification and validation efforts are carried out for each of the major analysis areas of the TERP activities., which could comprise on-site inspections, weather files update and calibrated simulations Next most significant activities complete in the solar Test Bench are reported, which record the weather that is use to validate and develop calibrated simulations.

### 6.1 Solar Test Bench

This section introduces a series of activities that were carried out to adjust and retrofit the STB during the calendar year of 2012. Some sensors were calibrated and updated and some new sensors were installed to the STB. Also, the Multi-Pyranometer Array (MPA) was installed onto the bench and the methodology to measure normal incident solar radiation using MPA was studied. In addition, the STB structure has been painted to white. The wirings in mechanical room have been organized.

#### 6.1.1 Solar Test Bench Setup

The whole STB setup has been detail described in the annual report for calendar year 2010. Thus, no more description about the setup is stated here, but the table for the sensor summary (**Error! Reference source not found.**) is updated due to sensor changes. This table gives the sensor name, make, model and serial number along with the multiplier, offset and unit.



Table 31. List of the sensors updated to the end of 2012

Index Number	Sensor Name	Make	Model	Serial Number	Multiplier	Offset	Unit
1	TOA/RH[1]	Vaisala	HMP45A	D2430006	0.18	-40	° F
					0.10	NA	%
2	TOA/RH[2]	Vaisala	HMP155A	G3220004	0.18	-40	° F
					0.10	NA	%
3	WS/WD[1]	Met One	034B	H4735	1.79	0.629	MPH
					712.00	NA	Degree
4	WS/WD[2]	Met One	034B	M5048	1.79	0.629	MPH
					712.00	NA	Degree
5	LICOR[1]	Licor	Li-cor	PY24908	72.59	NA	W/m <sup>2</sup>
6	LICOR[3]	Licor	Li-cor	PY15L25	75.59	NA	W/m <sup>2</sup>
7	LICOR[4]	Licor	Li-cor	PY49745	75.03	NA	W/m <sup>2</sup>
8	LICOR[5]	Licor	Li-cor	PY 74409	200.00	NA	W/m <sup>2</sup>
9	LICOR[6]	Licor	Li-cor	PY 74438	200.00	NA	W/m <sup>2</sup>
10	LICOR[7]	Licor	Li-cor	PY 74439	200.00	NA	W/m <sup>2</sup>
11	LICOR[8]	Licor	Li-cor	PY 474450	200.00	NA	W/m <sup>2</sup>
12	PSP[1]	Eppley	PSP	13673F3	125.63	NA	W/m <sup>2</sup>
13	PSP[2]	Eppley	PSP	16881F3	103.09	NA	W/m <sup>2</sup>
14	PSP[3]	Eppley	PSP	35417F3	112.74	NA	W/m <sup>2</sup>
16	NIP[1]	Eppley	NIP	14851E6	118.06	NA	W/m <sup>2</sup>
15	NIP[2]	Eppley	NIP	16620E6	117.79	NA	W/m <sup>2</sup>
17	BW[1]	Eppley	8-48	20226	96.99	NA	W/m <sup>2</sup>
18	BW[2]	Eppley	8-48	33886	98.62	NA	W/m <sup>2</sup>
19	CO2	Telaire	NA	NA	0.97	-123	PPM

## 6.2 2011 Year Summary of Activities

### 6.2.1 Wind Set Calibration

The wind set with the serial number of H4735 has some problems for the wind direction due to the potentiometer failure. The sensor was sent to the manufacture Met One Instruments to repair and calibrate on 3/22/2012, and received on 4/16/2012.

### 6.2.2 Installation of PSP3

A new PSP, named as PSP[3], was installed next to PSP[1] and at the same altitude (see Figure 64). The two sensors are pointed out in the picture. Figure 65 shows the comparison between two PSPs measurement for one week.

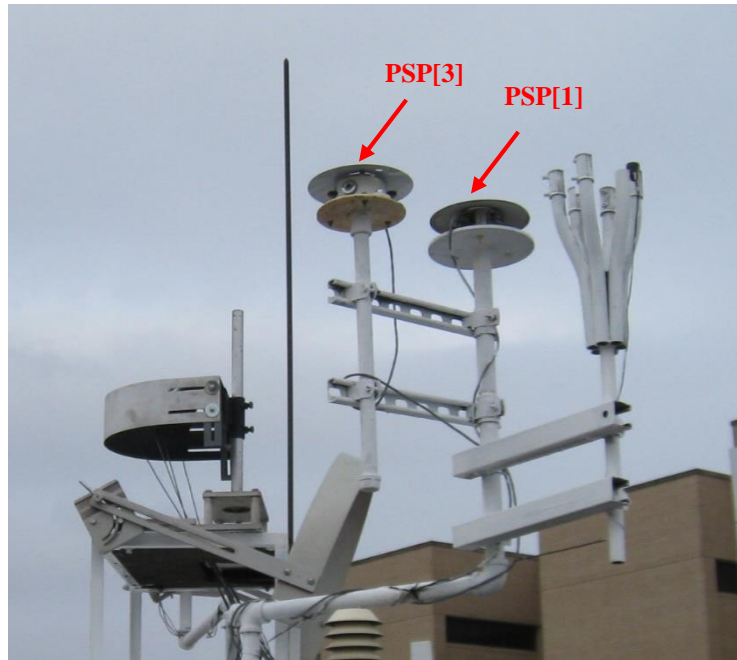


Figure 64: New installed PSP

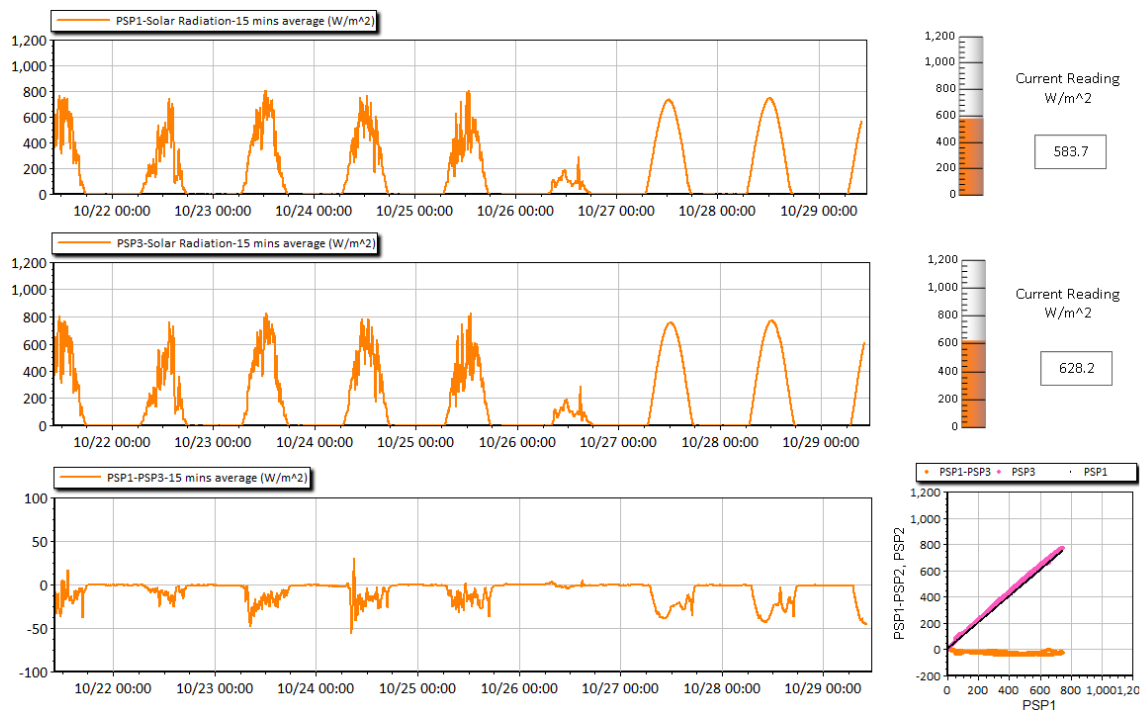


Figure 65: Comparison between the measurements from PSP[1] and PSP[3]

### 6.2.3 Paint for STB Structure

The STB has been painted to be white, and the pictures before and after painted are shown in **Error! eference source not found.** and Figure 67.



Figure 66: The whole STB before painted



Figure 67: The whole STB after painted.

#### **6.2.4 Wiring Organization**

Figure 68 and Figure 69 show the pictures of data logger before and after wiring organization.

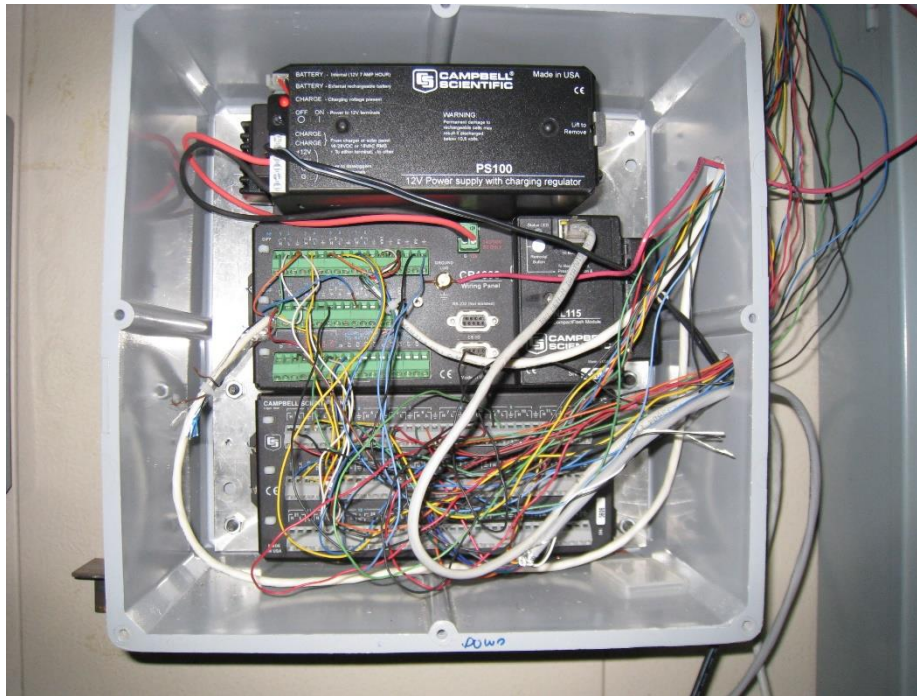


Figure 68: Data logger before wiring organization.

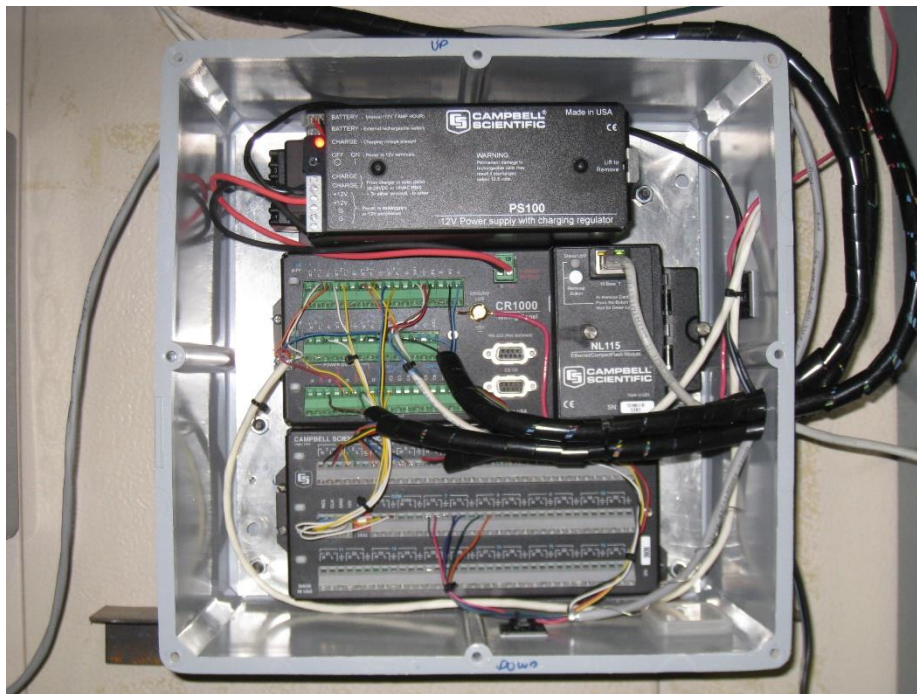


Figure 69: Data logger after wiring organization.



### 6.2.5 MULTI-PYRANOMETER ARRAY

The MPA consists of 4 LI-COR sensors: one sensor mounted horizontally, one 40 degree tilted sensor facing south, one 40 degree tilted sensor facing 60 degree east of south, and one 40 degree tilted sensor facing 60 degree west of south. And a shadow band is applied as an artificial horizon to block the reflected sunlight coming from the ground. The location, sensors and devices for MPA are shown in Figure 70 to Figure 72.

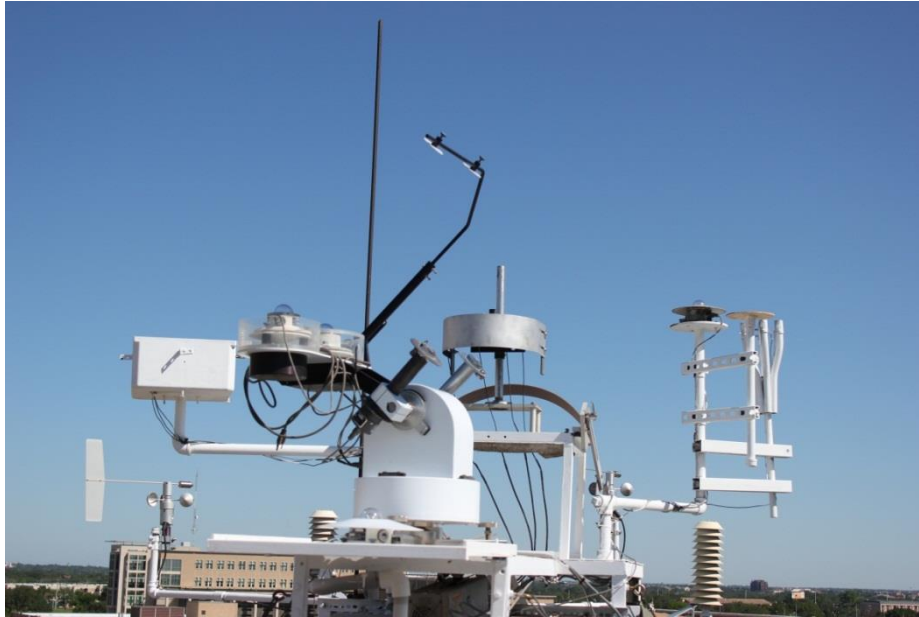


Figure 70: The Solar Test Bench after MPA installed





Figure 71: MPA structure

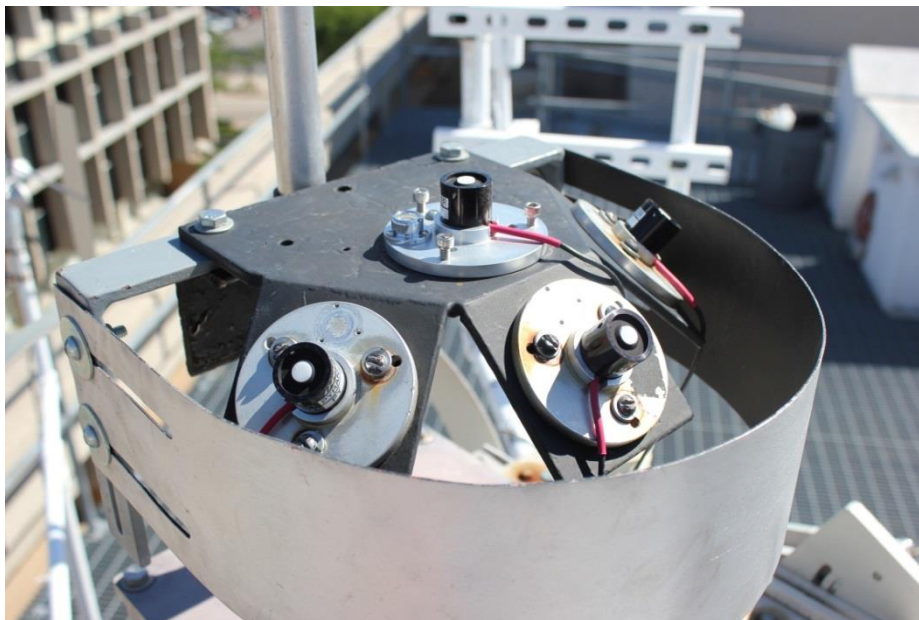


Figure 72: Placement of the 4 LI-CORs of MPA

### 6.3 Summary

- A new PSP has been installed next to PSP[1] and their measurements are compared.
- The whole Solar Test Bench structure has been cleaned and painted to be white.
- The wirings in the mechanical room have been organized.
- One wind sensor has been calibrated.
- Multi-Pyranometer Array has been installed on the bench to calculate normal incident solar radiation.

### 6.4 Acknowledgements

This task could not be completed without the help of many students among another Mr. Keehan Kim, Mr. Sunglok Do, Ms. Chunliu Mao and Mr. Stephen O' Neal from ESL, TAMU. Also the advice of Mr. Tom Kirk from EPPLEY Inc. was well appreciated.

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## 8.1 Appendix

This appendix presents an example of a method to evaluate the NO<sub>x</sub> emissions savings from the energy-efficiency programs. The ESL-Single Family program which is one of the energy-efficiency programs is selected to show the example. The following describes how data of the ESL-Single Family program are managed for the Integrated Savings process. In addition, Figure A-6 shows the overall flow diagram to manage the files processed in Integrated Savings.

1. Programs: The ESL-Single Family program is used for this example.
2. For savings/Generation Data: See the excel file “Singlefamily Data.xls”; Use the tab “2012 Data” which has the corresponding 2010 annual/OSD savings data based on 2008 base year generated by simulation<sup>43</sup>. Figure A-1 shows a screen-shot for the 2012 annual/OSD savings data.
3. The 2010 Annual & OSD eGrid: The ESL-Single Family program has two worksheet files for emissions factors; one for annual and the other for the OSD period pre-calculated emissions factors estimated from 2010 USEPA eGrid for Texas. The 2010 Annual & OSD eGrid files are “Singlefamily(annual\_2010eGrid\_25%).xls” and “Singlefamily(OSD\_2010eGrid\_25%).xls”, respectively. Figure A-2 shows the table of annual 2010 eGrid emissions factors using in Integrated Savings.
4. NO<sub>x</sub> Reductions & Projection for Different Programs: It can be found in the file “Singlefamily savings and projection.xls” that projected energy savings and NO<sub>x</sub> reductions for the ESL-Single Family program using 2010 eGrid emission factors. In the tab “Energy & NO<sub>x</sub> Savings Summary”, the energy savings summary projection plots are available, shown in Figure A-3.
5. Integrated NO<sub>x</sub> Reductions & Projection: Integrated NO<sub>x</sub> Reductions & Projection from all different programs are obtained by using the excel workspace<sup>44</sup> named as “Integrated Savings (2010eGrid).xlw”, which is to merge the results of all different programs. Figure A-4 shows a screen shot of example results using the excel workspace file.
6. Result of Integrated NO<sub>x</sub> Reductions & Projection: The resultant excel file “Integrated Savings Summary (2010eGrid).xls” is generated automatically by running “Integrated Savings Executable.xlw” and is located at the front of the worksheets shown in Figure A-4. The NO<sub>x</sub> emission reductions plots are under the tab “Energy & NO<sub>x</sub> Summary”, shown in Figure A-5.

<sup>43</sup> Most of the energy-efficiency programs have a separate excel file for their savings data input. However, the PUC SB7 and the Commercial Buildings programs have their savings data in the excel files named as “PUC SB7 savings and projection” and “Commercial savings and projection”, respectively.

<sup>44</sup> Microsoft Excel 2003 is recommended to run the excel workspace file.

	2008 Base Year	
	2012 permits	
	MWh	MWh/OSD
ANDERSON	4.82	0.01
ANDREWS	54.55	0.15
ANGELINA	44.15	0.12
ARANSAS	81.12	0.22
ARCHER	4.30	0.01
ATASCOSA	45.94	0.13
AUSTIN	16.81	0.05
BANDERA	-	-
BASTROP	40.65	0.11
BAYLOR	-	-
BEE	7.62	0.02
BELL	1,644.32	4.50
BEXAR	2,498.22	6.84
BLANCO	2.15	0.01
BORDEN	15.71	0.04
BOSQUE	1.78	0.00
BRAZORIA	1,535.80	4.21
BRAZOS	581.89	1.59
BREWSTER	7.14	0.02
BRISCOE	8.83	0.02
BROOKS	-	-
•		
•		
•		
•		
•		
VAN ZANDT	5.74	0.02
VICTORIA	93.99	0.26
WALLER	6.40	0.02
WARD	10.10	0.03
WASHINGTON	28.01	0.08
WEBB	590.28	1.62
WHARTON	64.35	0.18
WICHITA	126.76	0.35
WILBARGER	-	-
WILLACY	35.77	0.10
WILLIAMSON	2,529.13	6.93
WILSON	23.48	0.06
WINKLER	2.02	0.01
WISE	33.29	0.09
YOUNG	28.83	0.08
ZAPATA	-	-
ZAVALA	5.51	0.02
TOTAL	75,591.15	207.10

Figure A-1. Screen-shot of the 2012 Annual/OSD Savings Data for the “Singlefamily.xls” File.

Area	County	CM Zones								Total Nox Reductions (lbs)	Total Nox Reductions (Tons)
		H	N	W	S						
Houston- Galveston Area	Brazoria	0.0562032	3295.2379	0.0000071	0.3023	0.0000003	0.0008	0.0005265	21.5564	3317.10	1.66
	Chambers	0.0204500	1199.0000	0.0000026	0.1100	0.0000001	0.0003	0.0001916	7.8435	1206.95	0.60
	Fort Bend	0.0313463	1837.8597	0.0000040	0.1686	0.0000002	0.0004	0.0002937	12.0227	1850.05	0.93
	Galveston	0.0226620	1328.6890	0.0000029	0.1219	0.0000001	0.0003	0.0002123	8.6918	1337.50	0.67
	Harris	0.1486911	8717.8782	0.0000189	0.7998	0.0000009	0.0021	0.0013930	57.0295	8775.71	4.39
	Liberty	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Montgomery	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Waller	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Jefferson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Dallas/ Fort Worth Area	Orange	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Collin	0.0012932	75.8195	0.0079329	336.3120	0.0003832	0.8918	0.0000809	3.3134	416.34	0.21
	Dallas	0.0024826	145.5573	0.0152295	645.6476	0.0007356	1.7120	0.0001554	6.3611	799.28	0.40
	Denton	0.0001267	7.4264	0.0007770	32.9412	0.0000375	0.0873	0.0000079	0.3245	40.78	0.02
	Tarrant	0.0004742	27.8017	0.0029089	123.3199	0.0001405	0.3270	0.0000297	1.2150	152.66	0.08
	Ellis	0.0029920	175.4229	0.0183544	778.1222	0.0008865	2.0632	0.0001873	7.6662	963.27	0.48
	Johnson	0.0007256	42.5424	0.0044512	188.7053	0.0002150	0.5004	0.0000454	1.8592	233.61	0.12
	Kaufman	0.0059718	350.1342	0.0366343	1553.0882	0.0017695	4.1181	0.0003738	15.3014	1922.64	0.96
	Parker	0.0000012	0.0721	0.0000075	0.3198	0.0000004	0.0008	0.0000001	0.0032	0.40	0.00
	Rockwall	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Henderson	0.0006908	40.5008	0.0042376	179.6490	0.0002047	0.4763	0.0000432	1.7699	222.40	0.11
	Hood	0.0050771	297.6741	0.0311454	1320.3914	0.0015044	3.5011	0.0003178	13.0088	1634.58	0.82
El Paso Area	Hunt	0.0088463	518.6677	0.0047066	199.5352	0.0002273	0.5291	0.0052823	2672.6223	3391.35	1.70
	El Paso	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
San Antonio Area	Bexar	0.0138906	814.4172	0.0009368	39.7157	0.0000452	0.1053	0.1109355	4541.6419	5395.88	2.70
	Comal	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Guadalupe	0.0032029	187.7879	0.0002160	9.1576	0.0000104	0.0243	0.0255795	1047.2096	1244.18	0.62
	Wilson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Austin Area	Bastrop	0.0033782	198.0679	0.0002278	9.6589	0.0000110	0.0256	0.0269798	1104.5367	1312.29	0.66
	Caldwell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Hays	0.0008331	48.8470	0.0000562	2.3821	0.0000027	0.0063	0.0006537	272.3980	323.63	0.16
	Travis	0.0051785	303.6216	0.0003493	14.8063	0.0000169	0.0393	0.0413577	1693.1625	2011.63	1.01
	Williamson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Gregg	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Harrison	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Rusk	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
North East Texas Area	Smith	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Upshur	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Corpus Christi Area	Nueces	0.0128578	753.8617	0.0008672	36.7627	0.0000419	0.0975	0.1026870	4203.9512	4994.67	2.50
Victoria Area	San Patricio	0.0015100	88.5298	0.0001018	4.3172	0.0000049	0.0114	0.0120591	493.6911	586.55	0.29
	Victoria	0.0021192	124.2478	0.0001429	6.0590	0.0000069	0.0161	0.0169244	692.8745	823.20	0.41
	Andrews	0.0000037	0.2195	0.0000230	0.9738	0.0039003	9.0770	0.0000002	0.0096	10.28	0.01
	Angelina	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Bosque	0.0022204	130.1852	0.0136212	577.4618	0.0006579	1.5312	0.0001390	5.6893	714.87	0.36
	Brazos	0.0024089	141.2344	0.0112305	476.1113	0.0005425	1.2624	0.0047829	195.8097	814.42	0.41
	Calhoun	0.0009466	55.4989	0.0000638	2.7064	0.0000031	0.0072	0.0075598	309.4926	367.71	0.18
	Cameron	0.0063536	372.5184	0.0004285	18.1661	0.0000207	0.0482	0.0507425	2077.3692	2468.10	1.23
	Cherokee	0.0027392	160.5988	0.0168033	712.3673	0.0008116	1.8889	0.0001714	7.0184	881.87	0.44
	Coke	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Coleman	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Crockett	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Ector	0.0019215	112.6596	0.0006604	27.9954	0.0911346	212.0953	0.0146527	599.8731	952.62	0.48
	Fannin	0.0000041	0.2377	0.0000249	1.0546	0.0000012	0.0028	0.0000003	0.0104	1.31	0.00
	Fayette	0.0051867	304.1005	0.0103217	437.5816	0.0004986	1.1603	0.0283993	1162.6524	1905.49	0.95
	Freestone	0.0047643	279.3370	0.0292268	1239.0533	0.0014117	3.2854	0.0002982	12.2074	1533.88	0.77
	Frio	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Grimes	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Hardeman	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Haskell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Hidalgo	0.0053716	314.9397	0.0003623	15.3583	0.0000175	0.0407	0.0428994	1756.2786	2086.62	1.04
	Howard	0.0002411	14.1369	0.0007641	32.3923	0.1283942	298.8085	0.0009490	38.8512	384.19	0.19
	Jack	0.0030783	180.4839	0.0188839	800.5716	0.0009121	2.1228	0.0001927	7.8874	991.07	0.50
	Jones	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Lamar	0.0040001	234.5315	0.0245388	1040.3099	0.0011853	2.7584	0.0002504	10.2494	1287.85	0.64
	Limestone	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Llano	0.0040314	236.3670	0.0002719	11.5266	0.0000131	0.0306	0.0321966	1318.1132	1566.04	0.78
	McLennan	0.0056576	331.7109	0.0347066	1471.3680	0.0016764	3.9014	0.0003541	14.4963	1821.48	0.91
	Milam	0.0012686	74.3794	0.0000856	3.6272	0.0000041	0.0096	0.0101316	414.7807	492.80	0.25
	Mitchell	0.0000311	1.8251	0.0001910	8.0956	0.0324260	75.4641	0.0000019	0.0798	85.46	0.04
	Nolan	0.0000293	1.7153	0.0001795	7.6084	0.0304745	70.9225	0.0000018	0.0750	80.32	0.04
	Palo Pinto	0.0036129	211.8294	0.0221635	939.6106	0.0010705	2.4914	0.0002261	9.2573	1163.19	0.58
	Pecos	0.0000020	0.1155	0.0000121	0.5123	0.0020520	4.7756	0.0000001	0.0050	5.41	0.00
	Presidio	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Red River	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Robertson	0.0039506	231.6253	0.0055755	236.3690	0.0002693	0.6267	0.0246170	1007.8051	1476.43	0.74
	Taylor	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Titus	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Tom Green	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Upton	0.0000025	0.1491	0.0000156	0.6615	0.0026494	6.1660	0.0000002	0.0065	6.98	0.00
	Ward	0.0001995	11.6980	0.0012239	51.8886	0.2078335	483.6857	0.0000125	0.5112	547.78	0.27
	Webb	0.0042017	246.3505	0.0002834	12.0135	0.0000137	0.0319	0.0335565	1373.7872	1632.18	0.82
	Wharton	0.0021095	123.6824	0.0001423	6.0315	0.0000069	0.0160	0.0168474	689.7218	819.45	0.41
Wichita	0.0000121	0.7103	0.0000743	3.1505	0.0126190	29.3679	0.0000008	0.0310	33.26	0.02	
Wilbarger	0.0179710	1053.6544	0.1102430	4673.6888	0.0053249	12.3926	0.0011247	46.0463	5785.78	2.89	
Wise	0.0010202	59.8140	0.0062583	265.3166.							

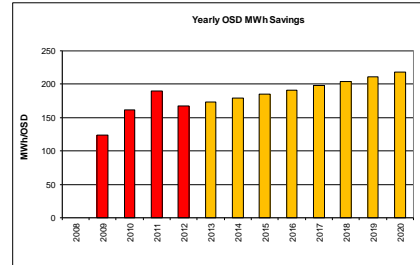
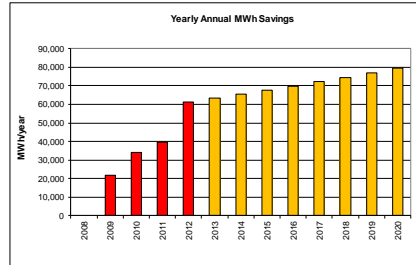


Energy savings summary: (program wise)

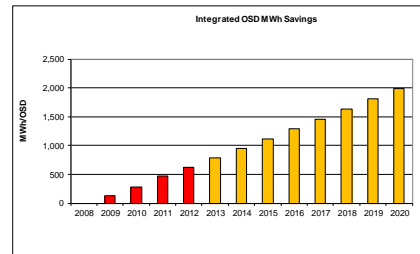
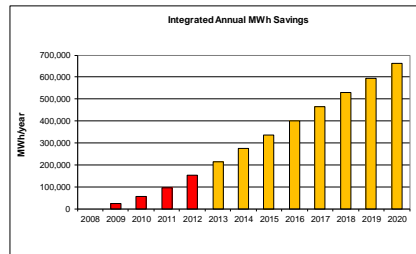
Base year	2008
Projection year	2020
Adjustment factors	
Annual degradation factor <sup>1</sup>	2.00%
T&D loss	7.00%
Initial discount factor <sup>2</sup>	20.00%
Growth factor	3.30%

Energy Savings Summary

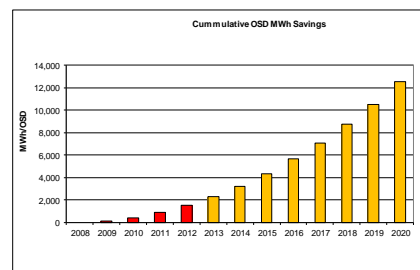
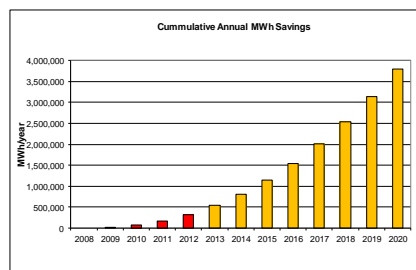
Year	Total Yearly Energy Savings	
	Electricity	Ozone Season Day
	Annual (MWh)	(MWh/day)
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0
2008	0	0
2009	21,748	124
2010	33,955	161
2011	89,597	190
2012	61,287	188
2013	63,309	173
2014	65,399	179
2015	67,567	185
2016	69,786	191
2017	72,089	198
2018	74,468	204
2019	76,928	211
2020	79,464	218



Year	Total Integrated Energy Savings	
	MWh	Ozone Season Day (MWh/day)
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0.00
2007	0	0.00
2008	0	0.00
2009	21,748	124.37
2010	55,268	283.25
2011	89,597	468
2012	153,171	626
2013	213,417	787.25
2014	274,548	950.68
2015	338,614	1,116.39
2016	399,668	1,285.61
2017	463,763	1,457.40
2018	528,956	1,632.28
2019	596,323	1,810.38
2020	662,861	1,991.89



Year	Total Cumulative Energy Savings	
	MWh	Ozone Season Day (MWh/day)
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0.00
2007	0	0.00
2008	0	0.00
2009	21,748	124.37
2010	77,017	407.62
2011	170,776	975.39
2012	323,948	1,501.71
2013	537,365	2,288.96
2014	811,913	3,239.64
2015	1,148,526	4,356.03
2016	1,548,194	5,642.00
2017	2,011,957	7,099.40
2018	2,540,914	8,731.67
2019	3,136,216	10,542.06
2020	3,799,077	12,533.95



NOx Savings Summary

Year	Total NOx emissions reduction (Tons) (2007 25% annual and ozone season a-Grid)	
	Electric	Ozone Season Day
2005	0.00	0.00
2006	0.00	0.00
2007	0.00	0.00
2008	0.00	0.00
2009	5.41	0.03
2010	13.62	0.07
2011	23.05	0.11
2012	37.74	0.15
2013	52.85	0.19
2014	67.77	0.23
2015	83.13	0.28
2016	98.73	0.32
2017	114.58	0.36
2018	130.71	0.40
2019	147.12	0.45
2020	163.83	0.49

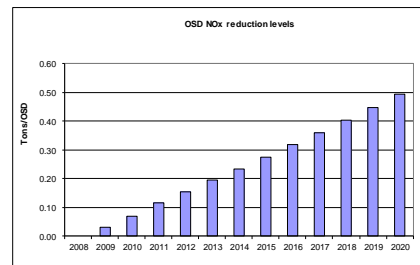
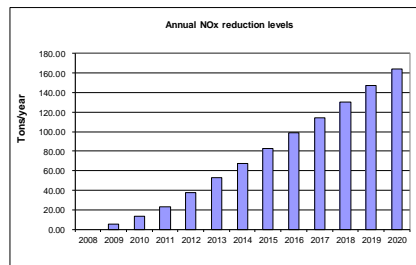


Figure A-3. Screen-shot of Selected Energy Savings and NOx Reductions Projections for the ESL-Single Family Program

Singlefamily savings and restriction  
Multifamily savings and restriction  
Commercial savings and restriction  
PUC (SB7) savings and restriction  
SECO savings and restriction  
SEER13 SE savings and restriction  
SEER13 ME savings and restriction  
Wind savings and restriction  
Integrated Savings Summary (2010eGrid)

	A	B	C	D	E	F	G	H	I	J	K	L
1	<b>Energy Savings Summary</b>											
2												
3	Base year	2008										
4	Projection year	2020										
5												
6												
7	ADJUSTMENT FACTORS											
8		ESL-Single Family <sup>18</sup>	ESL <sup>18</sup> Multifamily	ESL <sup>18</sup> Commercial	PUC (SB7) <sup>18</sup>	SECO <sup>18</sup>	Wind-ERCOT <sup>18</sup>	SEER13 Single Family	SEER13 Multi Family			
9	Annual Degradation Factor <sup>11</sup>	2.0%	2.0%	2.0%	5.0%	5.0%	0.0%	5.0%	5.0%			
10	T&D Loss <sup>9</sup>	7.0%	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%			
11	Initial Discount Factor <sup>12</sup>	20.0%	20.0%	20.0%	10.0%	60.0%	10.0%	20.0%	20.0%			
12	Growth Factor	3.3%	1.5%	3.3%	0.0%	0.0%	Actual Rates	N.A.	N.A.			
13	Weather Normalized	Yes	Yes	Yes	No	No	See note 7	Yes	Yes			
14												
15	Energy Savings Summary											
16												
17												
18	Program	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
19		Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)
20	ESL-Single Family	0	0	0	0	0	0	0	0	0	0	0
21	ESL-Multifamily	0	0	0	0	0	0	0	0	0	0	0
22	ESL-Commercial	0	0	0	0	0	0	0	0	0	0	0
23	PUC (SB7)	0	0	0	0	0	0	0	0	0	0	0
24	SECO	0	0	0	0	0	0	0	0	0	0	0
25	Wind-ERCOT	0	0	0	0	0	0	0	0	0	0	0
26	SEER13-Single Family	0	0	0	0	0	0	0	0	0	0	0
27	SEER13-Multi Family	0	0	0	0	0	0	0	0	0	0	0
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Figure A-4. Screen-shot of the Excel Workspace, “Integrated Savings (2010eGrid).xlw”

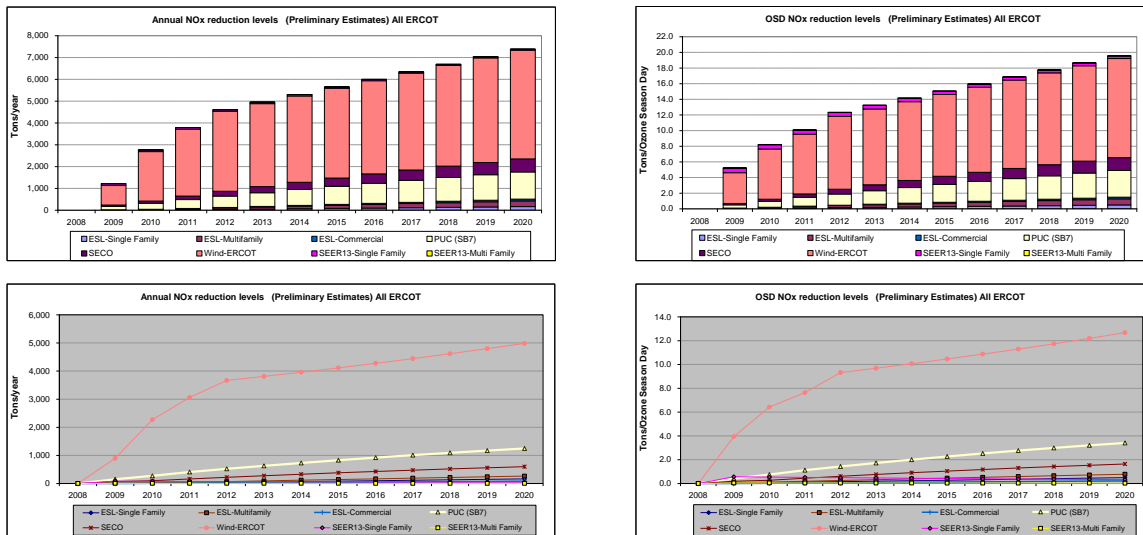
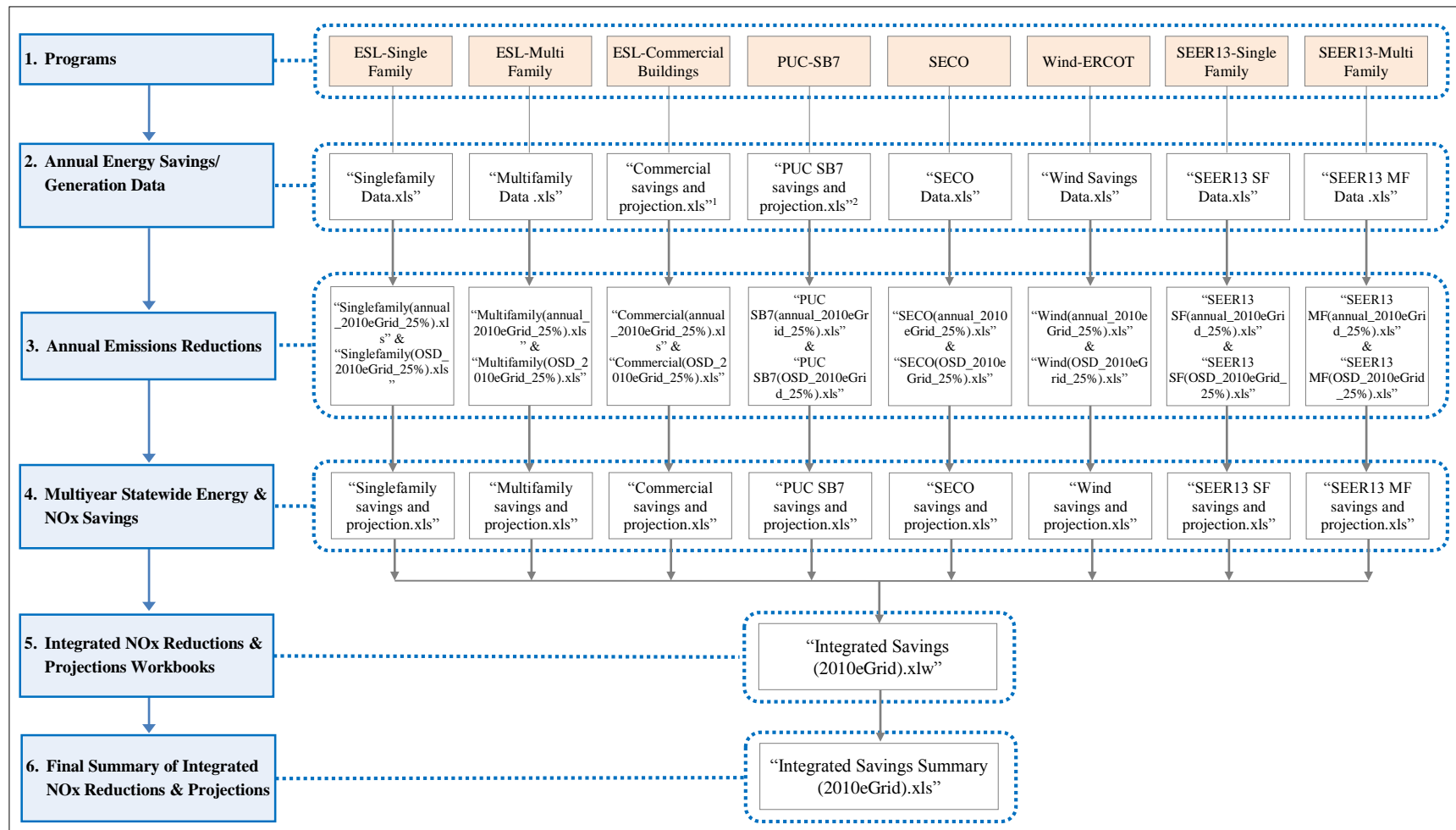


Figure A-5. Screen-shot of NOx Emission Reductions Plots under the Tab, “Energy & NOx Savings Summary” in the Worksheet “Integrated Savings Summary.xls”



Note: 1. Energy savings data for commercial buildings are found in two excel files: Commercial Data.xls & Commercial savings and projection.xls.

2. Energy savings data for PUC SB7 are found in their savings and projection excel files.

3. The emissions factors contained in eGRID used for electricity savings only.

Figure A-6. Overall Flow Diagram for the Files Processed in Integrated Savings